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Diesel Railway Traction

Railcars for Secondary Services

THE advantages which railcars in one form or another possess for branch lines and secondary work are now generally recognised, and if engineers and traffic officers could be fully persuaded of the reliability of this form of unit there is little doubt that a rapid extension of their use would be made. After over four years of actual experience the Belgian National Railways appear to be convinced of the all round merits of diesel traction, and no greater testimonial can be given than the placing of further orders after a thorough trial of the first examples. The three Maybach cars which went into service in 1930 have since been followed by 23 further vehicles and another three are still under construction. On all routes where they have maintained a service passenger receipts have shown an increase, for a more frequent train service, making more convenient connections at the various junctions, has been provided. But passengers are getting into the habit of travelling for the sake of travelling—rather than merely to arrive—in these attractive blue and cream cars, which are kept scrupulously clean. That is a feature the importance of which has been under-rated hitherto, and the general effect was borne in on us during a recent visit we paid to Belgium, when we were also specially impressed by the obvious self respect of the train staff. As to reliability, the figures of mileage and maintenance costs which are presented on another page of this issue speak for themselves, and we think that few operating officers would not be satisfied with a mileage of 45,000-55,000 and a maintenance and operating cost of 9d. a mile in the fourth year of service from cars seating 100 passengers, and having an absolute maximum carrying capacity of 170, in addition to luggage room.

Speed

FAST but safe and economical travel is the one commodity which railways can offer their patrons to an indisputably higher degree than any rival form of land transport, and, although for many years the average rate of travel was not so high as it might have been, there is now little doubt that the lesson of severe competition has proved to the railway companies that they can make speed a paying proposition. In the pages of this issue are described three new streamlined diesel trains, all of which are destined for high-speed service, and all of which have already run at speeds in excess of 85 m.p.h. While deploring the fact that not one of the three is of British origin, we believe that in the not far distant future our railways will be well to the fore in the use of such vehicles. In this country there are many routes eminently suitable for this type of traction, particularly between large towns situated one or two hundred miles apart which would be likely to appreciate the additional fast services that could be provided economically by high-speed railcars.

It is for this sort of service that the Burlington Zephyr has been constructed. The present two to five-car steam trains are handling the traffic with little or no profit, due largely to the expense of running and maintaining a relatively heavy train, and to the small difference in time between rail and road services. The owning company hopes that the Zephyr will have sufficient appeal to the public to attract more business, and there is little doubt that it will be successful in this respect, for apart from its studied comfort and striking appearance it is to maintain a four-hour schedule for the 251 miles separating Kansas City and Lincoln, an average speed of 62.8 m.p.h. inclusive of stops at St. Joseph and Omaha. The Zephyr will leave Kansas City at 8.0 a.m., and return from Lincoln in the afternoon, giving business men approximately four hours in the latter place, and eliminating two locomotives and six passenger cars with a total weight equal to eight times that of the Zephyr.

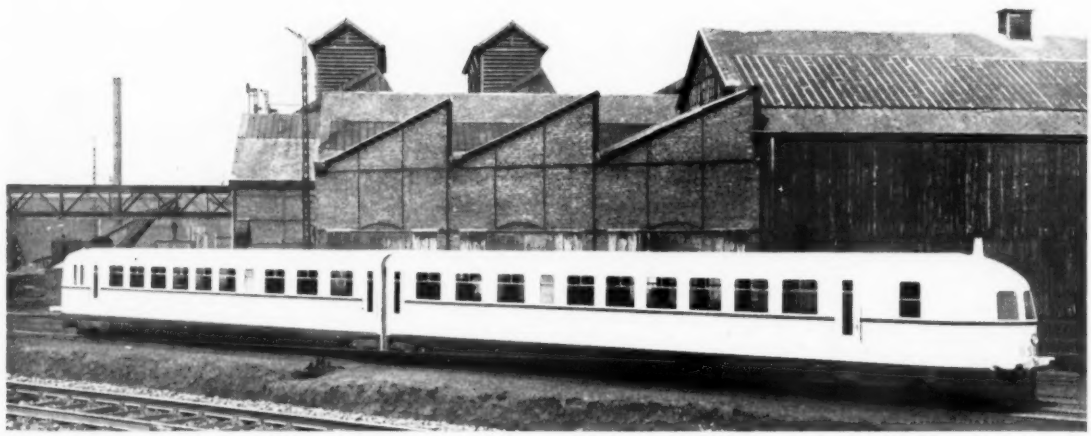
The Railcar Era

THE rapid advance of the diesel railcar within the last year or two has opened up an entirely new field of railway operation, and the diversity and number of its applications is likely to increase with even more rapidity in the near future, for it possesses to a high degree the capacity to provide a frequent and comfortable service at a remarkably low operating cost. It is to the commercial side of a railway that the increase in traffic is most attractive, but to the departments which are concerned with the preparation, running, and repair of the stock, it is the reliability which is of greatest moment. That reliability in operation far outweighs the effect of low fuel and lubricating oil consumptions is at once obvious to anyone who glances at details of operating costs such as those presented on another page of this issue. We believe that the 40 diesel trains now going into service on the Netherlands Railways, the 300-odd diesel cars in France and Germany, and the 700 or 800 similar vehicles in other parts of the world are but harbingers of a new era in railway working, in which the occasional heavy passenger train will tend to give way to the frequent and speedy railcar. That a good deal of money must contemporaneously be spent on developing the signal system is granted, but the expenditure should soon prove to have been justified by the specific and incidental advantages of diesel traction. When the signalling is developed and the standard of brakes and tracks in general raised to a level suitable for speeds of a high order, the diesel railcar will not be found lacking in its ability to maintain a fast and intensive service which will not only be appreciated by the travelling public, but which will also be run with a minimum of attention from the maintenance and operating staffs.

L.N.E.R. Diesel-Electric Railcars.—Two 250 b.h.p. double-bogie diesel-electric railcars have just been supplied by Sir W. G. Armstrong-Whitworth & Co. (Engineers) Ltd., to the London & North Eastern Railway. They are similar in all respects to the *Tyneside Venturer*, which has been working so successfully for some time over the steeply-graded lines on the Yorkshire coast. They are named *Lady Hamilton* and *Northumbrian*.

DIESEL RAILCAR DEVELOPMENT IN BELGIUM

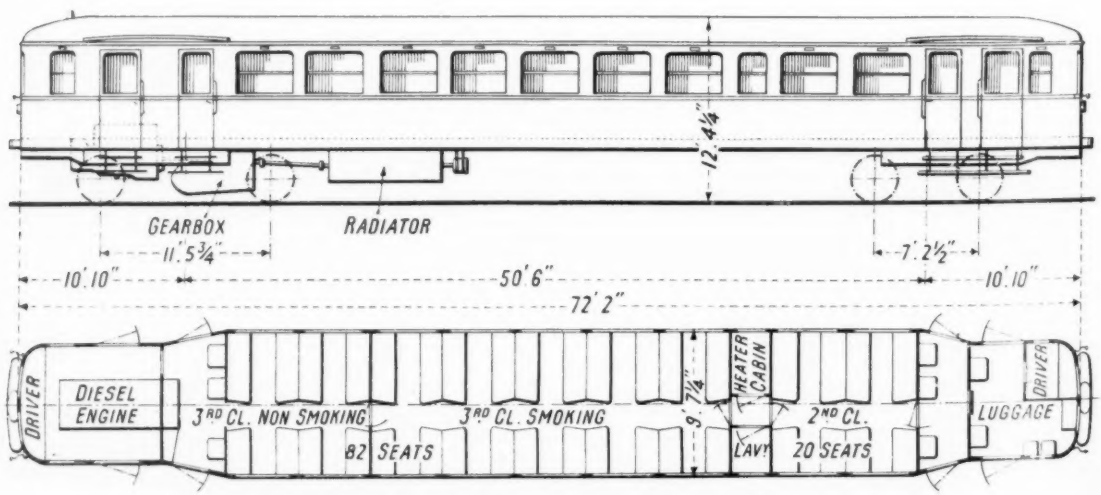
Several types are at work or under construction, and are providing better and more economical services over numerous lines



410 b.h.p. articulated streamlined diesel-electric express railcar which is now engaged in fast service between Brussels and Ghent. Photograph taken outside the works of the builders La Brugeoise et Nicaise & Delcuve

As a result of the experience gained with three 150 b.h.p. Maybach-engined diesel-mechanical railcars placed in service in 1930, and with a 200 b.h.p. Burmeister-engined diesel-electric railcar set to work at the beginning of 1932, the Belgian National Railway in the latter year decided to extend the use of such vehicles in order to check the drop in passenger receipts, which had become pronounced on many local and secondary services. Accordingly, a programme was drawn up for the construction of 25 new cars of various types as detailed in the first of the accompanying tables; with the exception of one streamlined articulated car, all these vehicles were intended for light stopping services without trailers, and 21 of them are now in regular operation.

For the sake of simplicity mechanical transmission has been preferred for all but two of the medium powered cars, but the highest-powered cars have electric drive. Although the four-wheeled Ganz cars scale only 17 tons tare, no special effort has been made to get a high power-weight ratio, the Belgian engineers considering complete reliability



General arrangement of diesel-mechanical railcar with 175 b.h.p. Maybach engine

to outweigh considerations of high accelerative capacity or minimum fuel consumption, and in this respect the four original cars have proved their worth.

150–175 b.h.p. Maybach Car

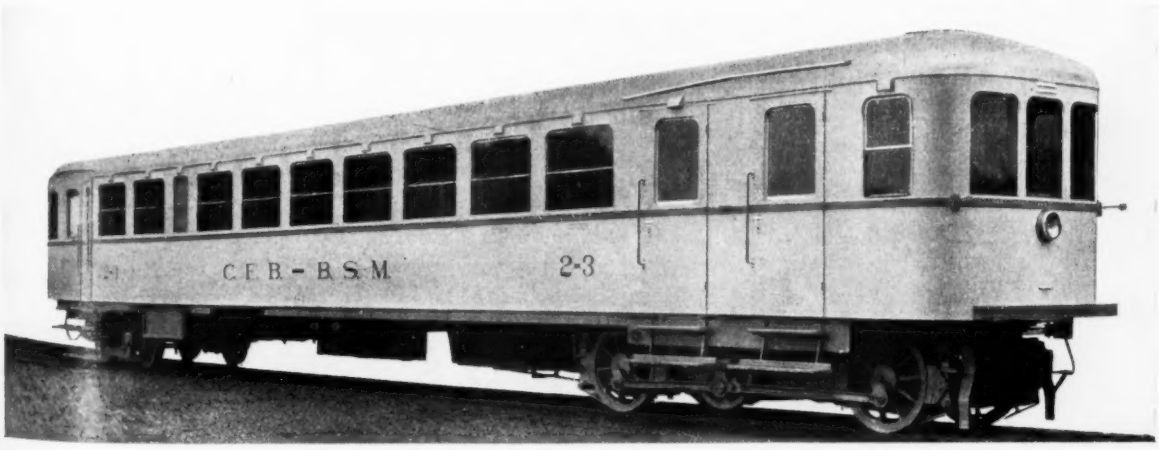
The general transmission and layout of the three 1930 cars and the 14 vehicles built last year by La Brugeoise et Nicaise & Delcuve are practically identical, and are indicated by the diagram on the opposite page. The mechanical portions of the older vehicles were constructed by the Eisenbahn Verkehrsmittel A.G., of Berlin, and the design follows the standard which has been used for Maybach cars of similar power in Germany and Denmark. The body framework and underframe are of steel sections and plates, but as the cars do not possess the normal type of buffing and draw gear, the ends of the underframe are of lighter construction than usual. A difference between the old and new cars is that the bodies of the former are riveted up, whereas welding has been extensively employed in the fabrication of the latter, and the panel plates are of copper-bearing steel. Weight has been further reduced in the 1933 vehicles by the adoption of aluminium-alloy doors, parcel racks, and fittings, and by the use of aluminium plates for the roof; in consequence the weight, with supplies but without passengers, has been reduced from 37·3 to 32·2 tons, the tare weight in each case being 0·75 ton less.

DIESEL RAILCARS OF THE BELGIAN NATIONAL RAILWAYS

Number of Cars	Car Builder	Engine Maker	B.H.P. Normal	B.H.P. Max.	Engine Speed, r. p.m.	Type of Transmission	Maker of Transmission	Max. Speed, m.p.h.	Number of Wheels	Weight without passengers Tons	Number of Seats	Luggage Space Sq. ft.	Date Placed in Service
3	E.V.A., Berlin	Maybach	175*	180	1,400	Mech.	Maybach	50	8	37·2	92	47·5	1–1–30 to 1–6–30
1	Deva, Vasteras	Burmeister & Wain	200†	200	850	Elec.	Asea ..	50	8	43·0	80	Nil	1–2–32
14	La Brugeoise et Nicaise & Delcuve	Maybach	175	180	1,400	Mech.	Maybach	50	8	32·0	104	43·0	19–4–33 to 25–8–33
5	Ganz	Ganz ..	120	150	1,200	Do.	Ganz ..	40	4	17·0	60	Nil	Jan.-April, 1934
1	La Dyle, Louvain	M.A.N.	140	160	1,400	Do.	T.A.G. ..	40	4	16·5	60	Nil	March, 1934
1	La Brugeoise et Nicaise & Delcuve	Maybach	210	220	1,400	Do.	Maybach	50	8	30·0	104	43·0	April, 1934
1	Do.	Do.	210	220	1,400	Elec.	Constr. electriques, Charleroi	50	8	30·0	104	43·0	U.C.
1	Do.	Do.	410	430	1,400	Do.	Siemens ..	75	12	70·0	185	54·0	May, 1934
1	S.E.M., Brussels	Carels	250	260	?	Mech.	S.L.M. ..	56	8	25·0	104	43·0	U.C.
1	Do.	Ganz	350	400	1,450	Elec.	?	50	8	30·0	104	43·0	U.C.

* Original engines, 150 b.h.p. † Two-stroke engine

As with the majority of Maybach cars, the diesel engine is mounted directly on a bogie with a triple suspension system. The jackshaft runs in plain bearings secured to the bogie frames, and is driven from the final shaft of the gearbox by reversing bevels. The carrying bogie is



One of the 175 b.h.p. Maybach-engined diesel-mechanical railcars of the Belgian National Railways

carried on S.K.F. roller bearings. A Westinghouse air brake applies two blocks on each wheel of both driving and carrying bogie, and gives a maximum deceleration equivalent to a stop in 165 ft. from 50 m.p.h. During several runs on these vehicles recently, we noted that service stops were made in 15-16 sec. from speeds of 42-45 m.p.h. without the slightest discomfort. A dead-man arrangement is incorporated in the engine control handle, and the various controls of the power plant are operated from either driving position and connected by cables running beneath the car body. The lighting installation comprises a 500-watt Bosch dynamo and a 180 amp. hr. lead battery which supplies current to the head and engine room lamps and to the passenger compartment lights. An interesting detail is a lamp secured to the underframe just above the driving bogie, which produces sufficient light to enable the driver to make his normal running inspection without the aid of a portable lamp. Heating of the passenger compartments is by hot water from an " Ideal Classic " coal burning stove, the water being kept in circulation by a small pump.

Contrary to all other applications of the Maybach 175 b.h.p. engine, the air injection equipment of the old 150 b.h.p. engine has been retained. The three 1930 cars were rated at 150 b.h.p., but have now been increased in output to 175 b.h.p. to correspond with the 1933 engines. Old and new engines are, however, exactly the same with the exception of the piston, which is now of aluminium alloy in place of cast iron and has a differently-shaped crown with a deep depression, giving, apparently, a better mixing of the fuel and air. The injection air is supplied by a three-stage compressor driven from the engine, and this compressor also supplies the engine starting air, the bottles for which are located beneath the car underframe. Unusual features of the starting system are that the first gear is engaged when the car is at rest, and that the starting air is admitted at a pressure which gives 49·7 m.p.h. The engine torque is taken up through a disc clutch operated by oil under pressure, and there is a short shaft with flexible couplings between the engine and gearbox, for although both units are mounted on the same bogie, they are independent.

Deva-Burmeister Car

In order to test the merits of electric transmission for relatively small outputs, the Belgian authorities in February, 1932, put into service in the Liége district a 200 b.h.p. double-bogie car built by the Swedish General Electric Co. (Asea) and its associated firm, Diesel-Elektriska Vagn Aktiebolaget (Deva). In accordance with the practice of those firms as applied to numerous rail-cars built for Swedish railways since 1914, the vehicle is of heavy construction, and is powered by a two-stroke Burmeister & Wain diesel engine which weighs approxi-

One of the early Maybach cars on the Belgian National Railways

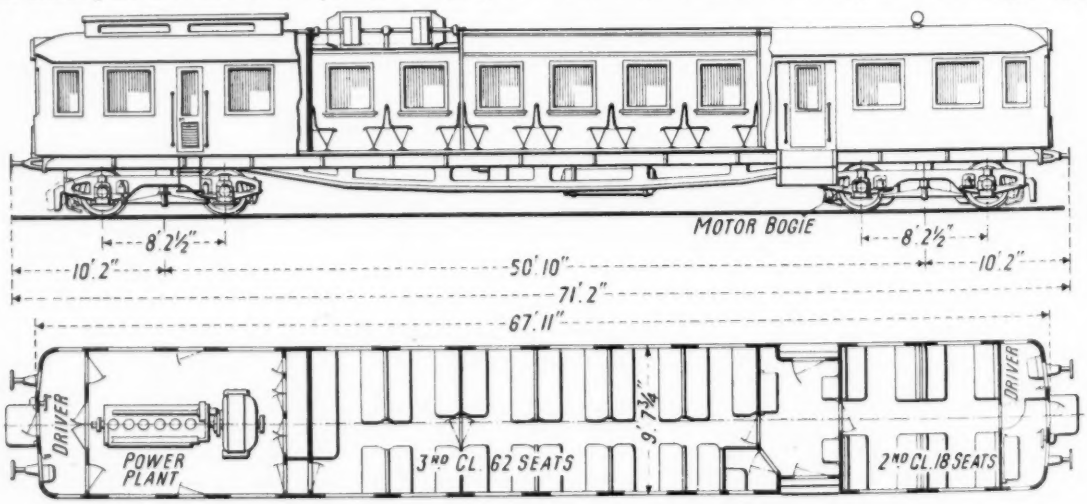


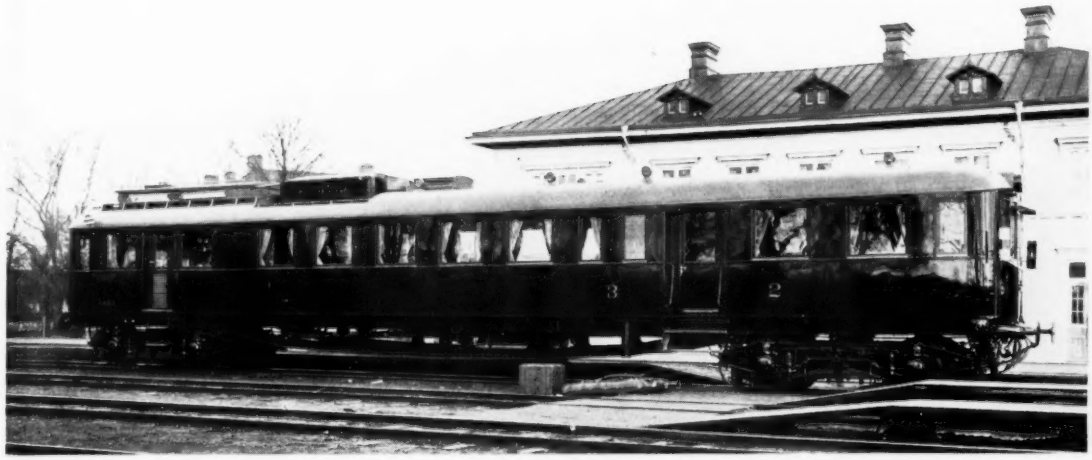
Diagram of 200 b.h.p. diesel-electric railcar with two-stroke engine

a torque several times that of the normal engine value. Fuel is stored in two tanks suspended from the engine-room roof, and these have a capacity sufficient for a journey of 600-700 km. The radiators are mounted beneath the floor of the car and are cooled by a fan driven from the gearbox through a long cardan shaft, as is shown in the accompanying diagram.

Four speeds are provided in the Maybach patent gearbox, and with normal engine revolution of 1,400 per min., give road speeds in either direction of 8·2, 20·0, 31·6, and

mately 34 lb. per b.h.p., or twice the weight of the Maybach 175 b.h.p. engine. The car scales 43 tons with supplies, but without passengers, or fully loaded, 48½ tons. No luggage accommodation is provided. The haulage of trailers is provided for, although this feature is rarely used in actual service, and standard buffing and drawgear is fitted.

After some short trial trips at the builder's works at Vasteras, this car made the journey to Belgium under its own power, following a roundabout route in order that



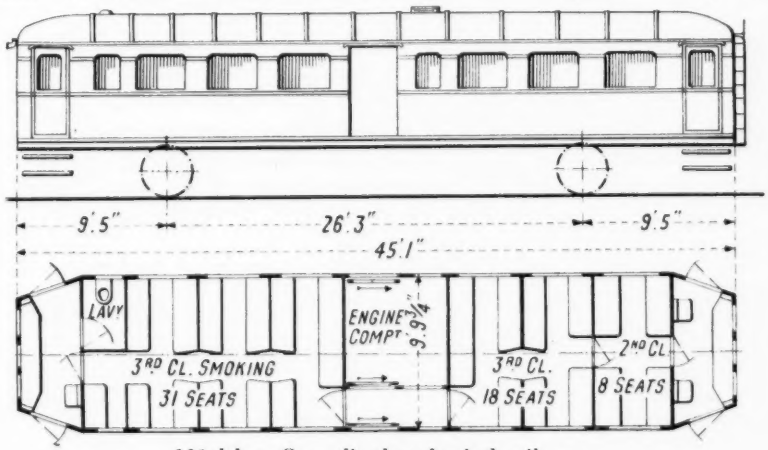
200 b.h.p. diesel-electric railcar used for passenger service in the Liege district

various railway authorities might have an opportunity of inspecting it. It ran from Vasteras via Helsingborg to the Elsinore train ferry, and then from Copenhagen through Korsor, Nyborg, Odense, and Strib to the Frederica train-ferry, and on through Aarhus, Frederica, Padborg, over the German frontier to Flensburg, and thence by way of Bremen, Aachen, and Herbesthal, to Liége, a distance of 1,550 miles. Following intensive trials conducted on the Louvain-Malines line by the railway engineers, the car went into revenue service in the Liége division, where it has remained ever since, working principally on the heavily graded Liége-Pepinster-Spa line, which has a long bank of 1 in 45.

The diesel engine has six cylinders 5·91 in. bore by 8·7 in., and develops its rated output at 850 r.p.m. It is direct-coupled to the main generator, and the two machines have a common bedplate. The cooling water and lubricating oil pumps, the radiator fans, and the air brake compressor are driven from the crankshaft, and in cold weather the engine-cooling water can be circulated through heaters in the car. Starting of the engine is effected electrically by using the main generator as a motor, current being obtained from a 110-volt 120-amp.-hr. Ni-Fe storage battery, which is charged by an auxiliary generator belt-driven from the armature shaft of the main generator. The traction motors are of the self-ventilated nose-suspended type, and to give a favourable weight distribution are mounted on the bogie at the opposite end of the car to the engine room. The air induced by the fan on the armature shaft is drawn through ducts and bellows from the top of the car body side. A dead-man handle attachment is fitted to the driver's controller in each driving cabin, and in the passenger compartments are emergency brake handles which, by actuating an electro-pneumatic relay, cut the traction motors out and apply the brake.

Oak and pine are used for the framework of the car body, which has outside panels of sheet steel and inside panels of three-ply wood with a mahogany surface. The floor of the passenger compartments is double and the space between filled with shavings. Linoleum covers the floor of the whole car with the exception of the lavatory, which has a layer of asphalt. Following Swedish practice, the outside of the roof is covered with impregnated canvas. The third-class seats are of plain varnished teak, but leather-covered spring seats are provided in the second-class compartment. The bogie frames are steel castings supported on each side by one long laminated spring having helical auxiliaries at each end; short helical springs are also fitted between each axlebox crown and the bogie frames. Roller bearings of the S.K.F. pattern are fitted to the axles. The underframe is of a type reminiscent of heavy main-line stock and is built up of steel plates and channels with stiffening angles.

Although not working in direct competition with the three Maybach diesel-mechanical cars of 1930, interesting comparisons should be possible, for not only is the transmission of a different type, but the engine is a heavy two-stroke machine compared with the light four-stroke Maybach unit, the body is wood with steel panelling, against the steel of the early EVA-Maybach vehicles and aluminium of the Brugeoise-Maybach cars, and the engine is mounted on the underframe instead of directly on the bogie. The operating costs (exclusive of capital and depeciation charges) per km. of the diesel-electric car is somewhat less than that of the Maybach diesel-mechanical vehicles. Operating data relative to the two types are



120 b.h.p. Ganz diesel-mechanical railcar

given at the end of this article, but despite the fact that there is little to choose between the two sets of operating figures presented, the Belgian National Railways authorities are not considering electric transmissions in the small-power range.

Ganz-Geared Railcars

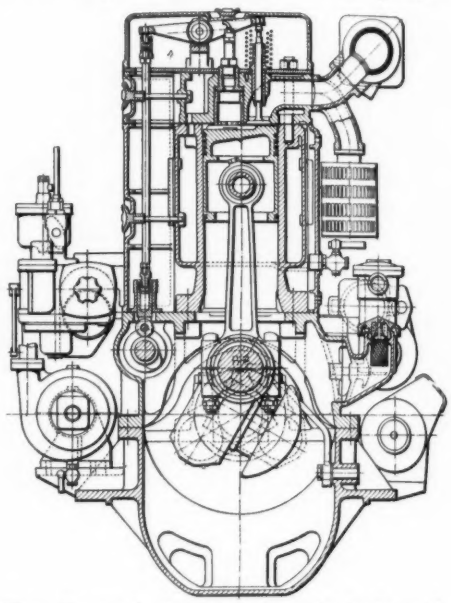
Apparently the success of the Ganz-engined diesel-mechanical railcars on the Hungarian State Railways, which were described in detail in the *Diesel Railway Traction Supplement* for March 24 and April 21, 1933, induced the Belgian engineers to give a trial to similar vehicles, and five four-wheeled cars built throughout by the Budapest firm have been introduced on local services round Haine, St. Pierre and Charleroi within the last four months. Yet another set of characteristics is presented by these cars, for the power-weight ratio is better than the Maybach cars, although the engines have as heavy a unit weight as the Burmeister & Wain machine. This is largely the result of the non-bogie type of construction, but it is worth noting that the maximum designed speed of these cars is only 40·4 m.p.h. compared with the 50 m.p.h. of the Maybach and Burmeister vehicles. The Ganz cars have a considerable wheelbase, 26 ft. 3 in. compared with the 21 ft. 0 in. of the Leyland diesel cars in Britain, but they ride quite well at the speed attained in operation.

Slung below the underframe, the Ganz engine projects but a little way above the floor of the engine room, which is spacious enough to give ample room for removing the cylinder heads and pistons and carrying out renewals or light repairs. The engine is of the Jendrassik type with a pre-combustion chamber and has six cylinders 5·91 in. bore by 7·3 in. stroke. It develops 120 b.h.p. at 1,200 r.p.m., but experience in Hungary has shown this to be a very conservative rating, and a maximum output of 150 b.h.p. is available for railway traction. The type of fuel pump fitted enables the injection to be effected at a pressure and velocity independent of the speed and load of the engine. It is thus possible to obtain efficient combustion at low speeds, and the engine operates with equal reliability and almost constant torque at all speeds between 350 and 1,200 r.p.m.

The following table gives a brief comparison of the Ganz and Maybach engines as used on the Belgian National Railways:—

	Ganz.	Maybach.	Maybach.
Number of cylinders	6	6	12
Bore and stroke, in.	5·91 × 7·3	5·51 × 7·1	5·91 × 7·9
Rated b.h.p.	120	175	410
R.p.m.	1,200	1,400	1,400
Brake m.e.p., lb. per sq. in.	67·0	97·0	91·5
Piston speed, ft. per min.	1,460	1,655	1,840
Weight, lb. per b.h.p.	34·0	13·9	9·25
Injection	Pre-comb.	Direct	Direct
Injection pressure, lb. per sq. in.	1,220	2,800–3,000	2,800–3,000
Compression pressure, lb. per sq. in.	500	575	575
Max. cyl. pressure, lb. per sq. in.	600	750–780	750–780

The transmission of the Ganz cars consist of a four-speed constant-mesh gearbox mounted close to the flywheel end of the engine, and a long cardan shaft with flexible couplings which leads thence to the bevel reversing gear on the centre of one axle. The remaining axle is of the carrying type, so that the adhesion weight with a full complement of passengers is approximately 10½ tons. Gear changing and reversing are effected pneumatically from either cab. The silencer is located below the body, and the exhaust gases are ejected horizontally at a low level, as in an automobile. Radiators for water and lubricating are located on the roof at the ends of the car, and a small lever in one of the driving cabins enables part of the windage area to be blocked off in hot weather. A fan is not used, the natural draught of motion being sufficient to ensure adequate cooling. The engine cooling water can be circulated through the car for heating purposes.



Cross-section through 120 b.h.p. Ganz engine as used on the Belgian National Railways

410 b.h.p. streamlined express diesel-electric railcar

In one of the driving cabins is an ingenious gauge which, upon the turning of an adjacent switch to positions marked 1, 2, and 3, will show respectively the inlet and outlet temperature of the cooling water and the temperature of the water in the car heating circuit. On the same board is mounted an engine revolution counter, but in the cab at the other end this is replaced by a speed indicator, and it is difficult to see just why, if these fittings were considered necessary, they were not duplicated. An engine control handle and a Westinghouse brake driver's valve are mounted to the right-hand side of the cab, and the reversing

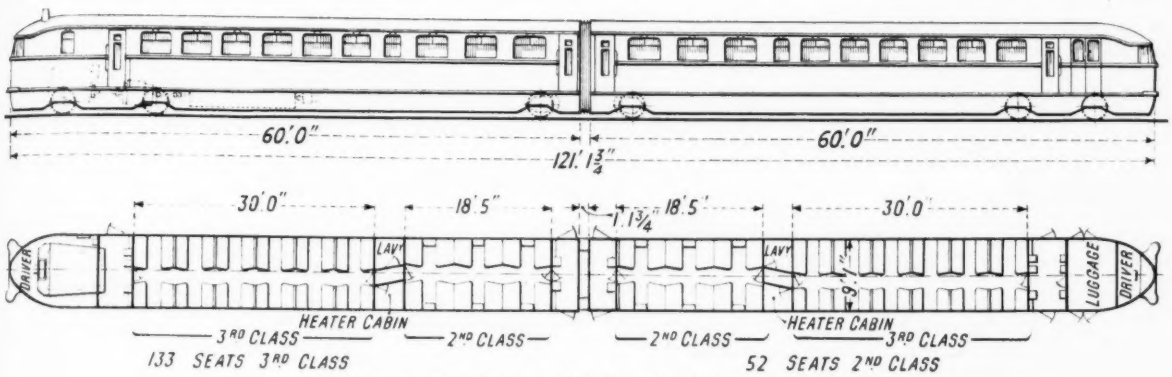


Diagram of Belgian 410 b.h.p. diesel-electric train

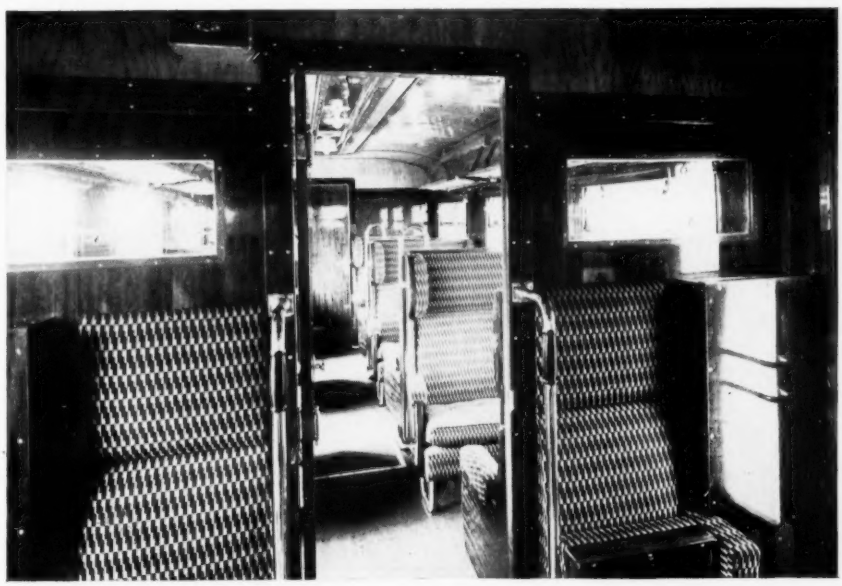
handle on the left-hand side. Against the Westinghouse valve is a hand brake, and the fittings are completed by a voltmeter for the lighting circuit, head and interior light switches, a push button for an electrically-operated klaxon horn, and a switch for a pneumatic horn. A dead-man foot pedal is incorporated in the control, but this was disconnected at the time we inspected the Ganz car.

Aluminium panels are used for the car body, which is constructed in such a manner as to form an integral unit with the underframe. Draw and buffing gear of the ordinary pattern not being carried, advantage has been taken of the omission to make the framing very light, and the net tare weight of 16½ tons gives a weight of 615 lb. per seat, or 7·3 b.h.p. per ton. The interior of the car is finished in plain varnished wood, with wooden seats in the third-class compartments, and upholstered seats in the second class. A certain amount of light luggage can be carried above the engine, and lavatory accommodation is provided, although the cars are used only on local services.

Articulated Express Railcar

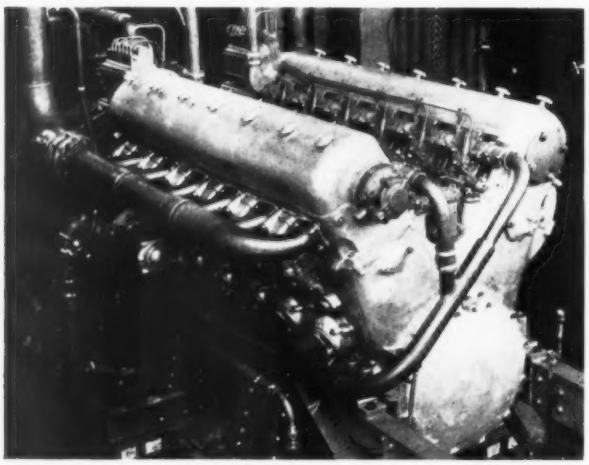
The highest development of the diesel railcar in Belgium is the streamlined articulated unit with one 410 b.h.p. Maybach engine and electric transmission, which was put into regular operation between Brussels (Midi) and Ghent with the inauguration of the summer timetables on May 15. Prior to this it had been tested by the locomotive department of the Belgian National Railways, under the auspices of Monsieur P. L. N. Ghilain, Ingénieur-en-Chef, and his railcar assistant, M. E. Hennig. On May 9, the Belgian Minister of Transport and several members of the Belgian Parliament made a private trip from Brussels to Ghent and back, but before this, on May 7, a trial trip to Namur was made by the railway engineers, in the course of which a speed of 86 m.p.h. was reached. A number of braking trials were conducted on May 8 between Brussels (Quartier Leopold) and Charleroi, and on these we noted stops from 63·64 m.p.h. in 29-30 sec. without any discomfort to the party, most of whom were standing in the centre gangway and not awaiting the brake application. In normal service it is not intended that the car shall exceed 65 m.p.h.

Constructed by La Brugeoise et Nicaise & Delcuve at its La Louvière works, the car consists of two vestibule bodies supported on three bogies, the first of which comes the engine and generator, the second, under the articulation pivot, the two traction motors; the remaining bogie is of the carrying type. Each bogie frame is constructed of welded steel in the form of a box girder in one with the underframe, and has outside panels of upper-bearing steel. The roof is of steel and aluminium alloy with roofsticks of steel and wood. The inner side panels of the car are of wood obtained from the Belgian Congo, but the end panelling and doors are of plywood made by De Coene Hères, stained and varnished with a mahogany finish. No insulating boards are used on the doors or panels between the engine room and passenger compartment. All the seats in both second and third-class compartments have stainless steel tubular frames, and have small tables between them, secured to the side panels; in the smoking compartments these tables have sunken ash-trays. The second class seats are upholstered, but those in the third class compartment are of wood, comfortably shaped. Above each window is a " Bob " ventilator with an inside



Interior of second class compartment of 410 b.h.p. diesel-electric train

regulating screw, and each window has, in addition, a spring-roller blind. The wooden floor-boards are covered with linoleum. The light luggage racks are of manganese-aluminium alloy with end castings of chromium-plated brass. This material is also used for the reflector plate



Maybach 12-cylinder 410 b.h.p. diesel engine

which runs right through down the ceiling of each car above the centre aisle, and contains the three main lights. The window frames are of a non-corrodible light metal and the glazing is of Splintex; small sliding glass shutters above the windows provide additional ventilation without causing draught over the seats. The layout of the seats and the lavatory and luggage accommodation may be seen in the accompanying diagram. When the entrance and exit doors are opened the footboards are automatically dropped into position by means of compressed air. The interior decoration has been designed by an architect, M. Van de Velde, who has succeeded in producing a thoroughly pleasing effect.

Heating of the passenger compartments is effected by hot water circulated by an electrically-driven pump from two " Ideal Classic " anthracite-fired stoves located in special compartments near the mid-length of each car. The consumption coal averages about 65 lb. per stove over a working day of 16-18 hr., and heating of the water is automatically controlled to a maximum temperature of 65 deg. Fah. The heating pipes are carried along the bottom of each side panel and are enclosed in light metal ventilated casings where they pass between the seats.

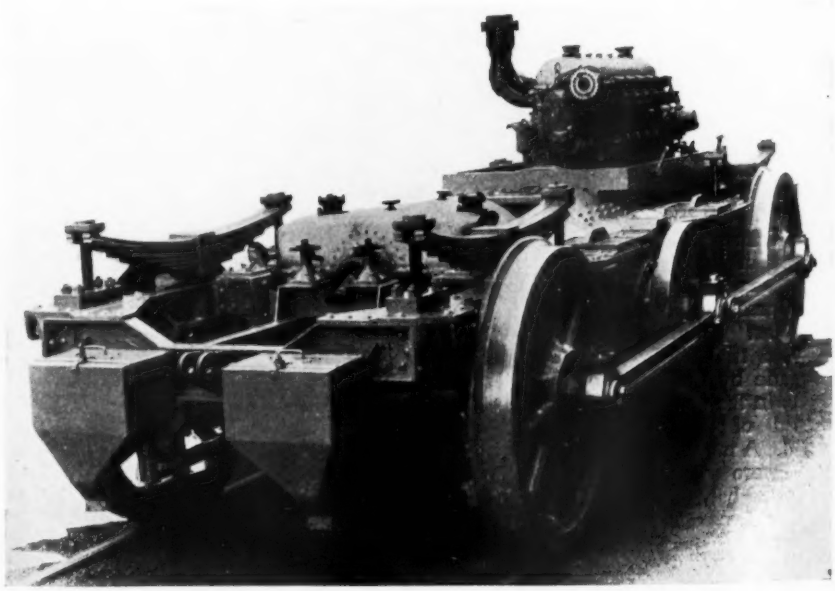
Mounted on a triple-suspension four-wheeled bogie of the Wumag type, the engine is of the well-known Maybach 12-cylinder V design, developing 410 b.h.p. at 1,400 r.p.m., as fitted to the Flying Hamburger and the diesel-electric trains of the Netherland Railways. All axles run in S.K.F. roller-bearing boxes, and the wheels are braked pneumatically and hydraulically. The Westinghouse automatic brake has two small cylinders per wheel which actuate one block each on a brake drum attached to the wheel, the wheel being specially ribbed to provide a current of air to cool the drums. The hydraulic brake acts on the end bogies only, and the control is embodied with that of the air brake. Four small cylinders are placed on each of the end bogies and double pistons actuate blocks on the brake drums by the pressure of oil admitted to the cylinders.

The electric transmission components were manufactured by Siemens-Schuckert, and consist of the usual directly-coupled main generator, with a capacity of 260 kW. and a maximum voltage of 850, and two nose-suspended traction motors, coupled permanently in parallel, with a continuous capacity of 106 kW. at 725 volts. An auxiliary generator of 6 kW. capacity is fitted, and the Gebus electro-pneumatic control system is embodied. The starting and lighting battery is of the lead type, made by the A.F.A., of Berlin, and has 48 cells of 240 amp. hr. capacity. Against the tare weight of 67½ tons, the diesel engine gives an output of only 6·08 b.h.p. per ton, or 5·5 compared with the full weight of 74 tons.

Other Diesel Cars

As indicated in the first of the tables accompanying this article, there are a further five diesel cars belonging to the Belgian National Railways, but three of these have not yet been delivered. As an alternative to the Ganz cars, the Soc. An. La Dyle, of Louvain, two months ago delivered a four-wheeled car with a 140 b.h.p. high-speed M.A.N. engine running at 1,400 r.p.m., and weighing 14·5 lb. per b.h.p. The mechanical transmission was constructed by the Triebwagenbau A.G., of Berlin, and the tare weight of the car is a trifle less than that of the Ganz 120 b.h.p. vehicles.

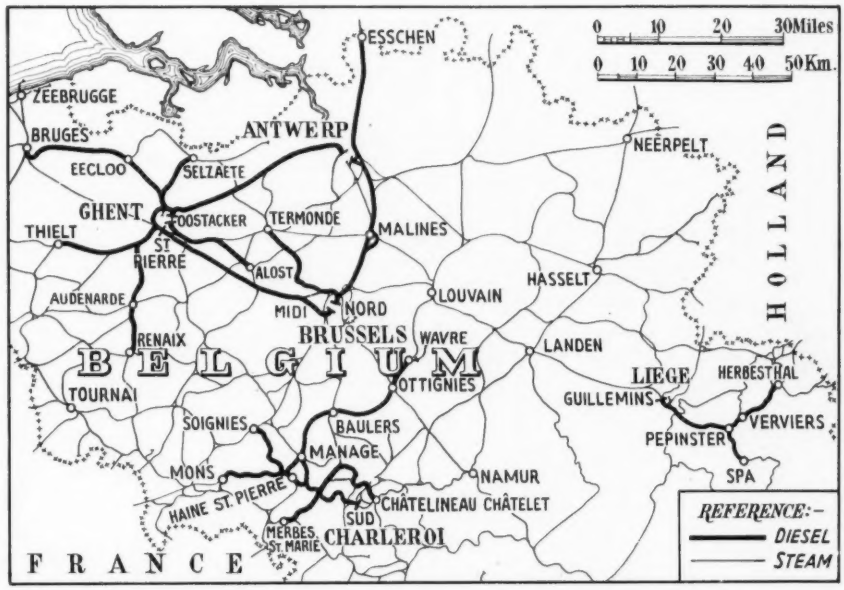
Two 210 b.h.p. double-bogie cars with Maybach engines were ordered from La Brugeoise et Nicaise & Delcuve, and the first of these, that with mechanical transmission,



175 b.h.p. Maybach engine and four-speed gearbox mounted on driving bogie of Belgian railcar

is now at work between Brussels, Antwerp and Esschen. Its seating capacity and general layout are similar to those of the 175 b.h.p. cars, but a Vulcan hydraulic coupling is incorporated, and the higher engine power makes available a greater accelerative capacity. The other Maybach car has electric transmission, but it is not expected that the weight will appreciably exceed the total of the geared vehicle. The Maybach engine fitted to these cars is of the six-cylinder in-line type, and is depicted in one of the accompanying illustrations. It follows the general lines of the 175 b.h.p. engine, but has cylinders of the same size as those employed in the 410 b.h.p. unit, viz., 5·91 in. bore by 7·9 in. stroke; the rated speed is 1,400 r.p.m., and the weight 13·5 lb. per b.h.p.

Of the two remaining cars, it was the original intention to fit the first with a 220 b.h.p. engine built by Van den Kerchove, of Ghent, but this has been abandoned, and the Ganz company have developed a 250 b.h.p. engine for use in conjunction with mechanical transmission with oil-operated gears as made by the Swiss Locomotive Company. This engine will be manufactured by Carels, the Belgian licensees of the Ganz-Jendrassik engine, and this firm will also supply the 350 b.h.p. Ganz-type engine for the last vehicle. The construction of this car is in a very early stage, but in view of the power it is anticipated that electric transmission will be employed. No further programme will be drawn up until the behaviour of the most recent cars has been observed.



Map of Belgian Railway system, showing lines at present operated by diesel railcars

Operation and Results

Interesting figures are now available for the first three Maybach diesel-mechanical cars and the Burmeister diesel-electric vehicle. The majority of the service of the former type has been in the Ghent division, working from that town to Eecloo and Bruges, Thielt, Renaix, and Antwerp. The first car went into service on January 1, 1930, and the other two on June 1, 1930. Up to May 1, 1931, these three cars had covered a total of 162,000 miles, and from January 1, 1930, until October 1, 1933, the aggregate mileage was 552,500, giving an average daily mileage of 146 for the 3,802 days in service. During 1932, the average mileage per car was 57,500 at a fuel consumption of 1·3 lb. per mile, and an operating plus maintenance cost of 2·86 Belgian francs* per mile. The Burmeister-Deva diesel-electric car from February 1, 1932 to October 1, 1933, ran 89,000 miles, or a daily average of 146 miles for the 607 days in service. During 1932, the distance covered was 52,700 miles, the fuel consumption, over heavily-graded lines, was 2·66 lb. per mile, and the operating plus maintenance cost, 2.48 Belgian francs per mile.

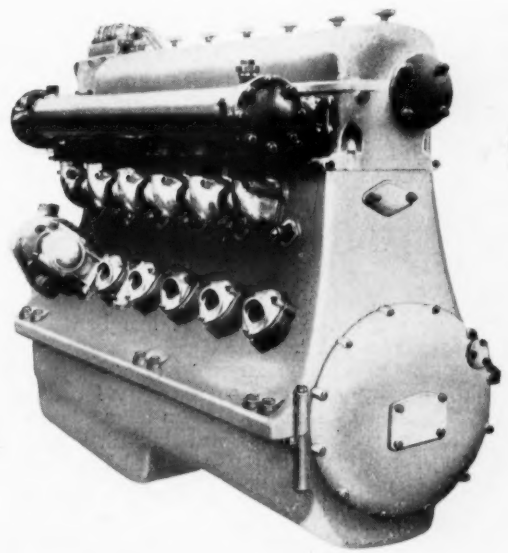
The table in the next column gives the total covered by each of the first four diesel railcars of the Belgian National Railways up to December 31, 1933.

The three Maybach cars referred to above, along with the 14 vehicles supplied last year by La Brugeoise et Nicaise & Delcuve, are now making individual monthly mileages of 4,300 to 5,000, while the Ganz cars, which are being run-in, are covering 2,000 to 2,500 miles a month. In general, the Maybach-engined cars are laid off regularly

OPERATING DATA OF BELGIAN CARS

Car	Burmeister	Maybach 1	Maybach 2	Maybach 3
Transmission	Electric	Mech.	Mech.	Mech.
Date place in service ..	1–2–32	1–1–30	1–6–30	1–6–30
Annual kilometrage, 1930	—	89,648	41,405	53,335
1931	—	69,310	85,928	80,776
1932	84,899	87,937	93,310	96,972
1933	81,291	88,766	65,694	79,640
Total kilometrage ..	166,190	335,661	286,337	310,723

Working cost per km. for 1933, Belg. francs	Average for three cars.
Fuel	0·24
Lubrication	0·05
Wages	0·43
Maintenance and repair ..	1·74
Sundry	0·09
Total	2·55



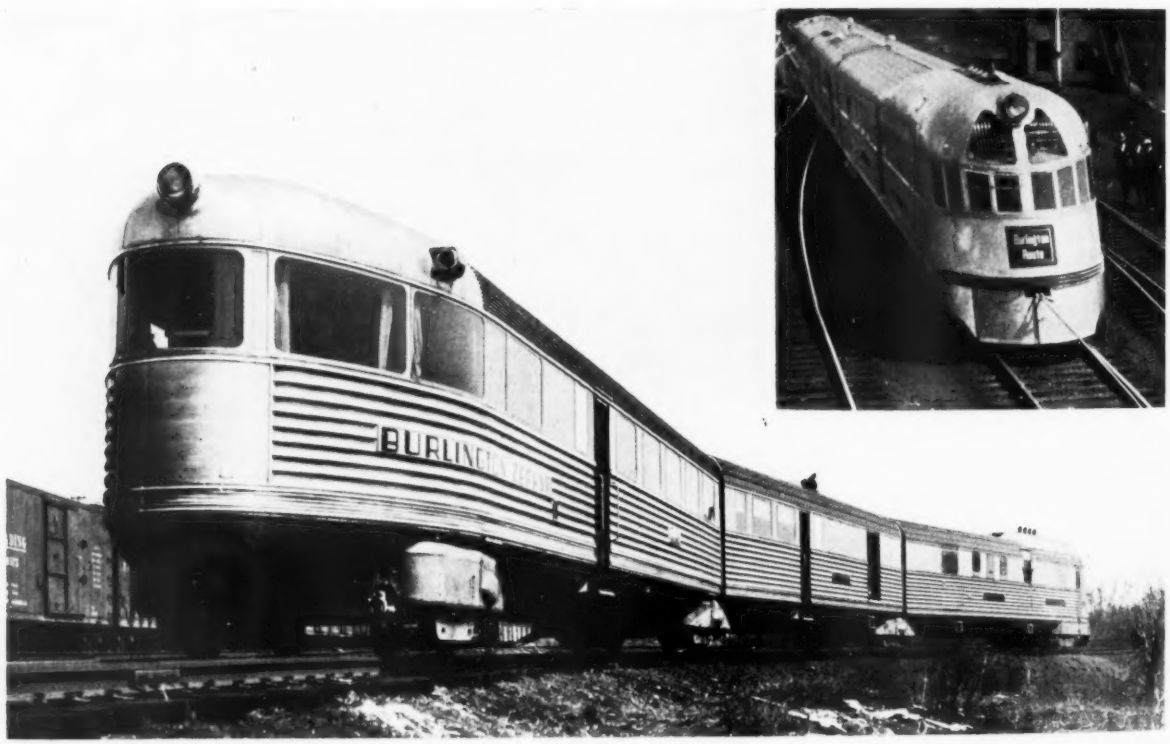
210 b.h.p. light-weight Maybach engine as used on the latest railcars of the Belgian National Railways

* Present rate of exchange, 109 Belgian francs to the £.

THE BURLINGTON ZEPHYR

America's latest effort to regain long-distance passenger traffic possesses many advanced features, and is to operate in 60 m.p.h. service over long distances

FOLLOWING upon the distillate-engined high-speed train acquired a month or two ago by the Union Pacific Railroad, a diesel train of even more remarkable characteristics has just been constructed by the E. G. Budd Manufacturing Company for the Chicago, Burlington & Quincy Railroad, and by reason of the propensity for speed which it is anticipated to possess, it has been dubbed the Burlington Zephyr. At the moment the Zephyr is making a tour of the principal cities in the United States, and during the summer will be shown at the Chicago Exhibition, after which it will go into express service on the owning company's line between Kansas City, Omaha, and Lincoln.



The Burlington Zephyr, America's 100 m.p.h. streamlined train, on test near the works of the builders, the E. G. Budd Manufacturing Company

Designed for a maximum speed of approximately 110 m.p.h., the streamlined shape necessary for such speeds was determined by tests undertaken at the Massachusetts Institute of Technology, which indicated that at an operating speed of 95 m.p.h. the total resistance would be about 47 per cent. of that of a three-car train of conventional shape and similar weight. A number of well-known architects collaborated in the design of the car interior in order to provide the utmost in comfort and attractiveness. The train consists of three articulated bodies carried on four bogies, the one beneath the engine room being motored, and, in a length of 197 ft. and a tare weight of 87½ tons, seats 72 passengers and has a buffet and large storage room for baggage and mails.

The Body Structure

Practically the whole of the body structure from floor to roof shares in carrying the load, and is built up in truss form of stainless steel, shot-welded by the Budd process. The truss frames are generally of flanged box sections with cover plates joined by Shotweld, the steel used having an ultimate strength of 67 tons per sq. in. and an elastic limit of 54 tons per sq. in. The floor structure is made up of corrugated stainless steel sheet, the bottoms of the corrugations of which are welded to a flat sheet, and both in turn welded to longitudinal stringers, of which there are eleven across the car. These are further secured to transverse supports built into the car frame, and the flooring thus forms a stiff horizontal girder through which end loads are distributed to the side girders. The roof constitutes a primary structural member, and takes up the entire compression load. It is built up of longitudinal corrugated sheets welded to roof carlines, and is locally reinforced at the points of maximum stress. In cross-section the car frame is of almost tubular form, but the portion below the floor is not a main part of the load-carrying structure, and the trussed centre sills

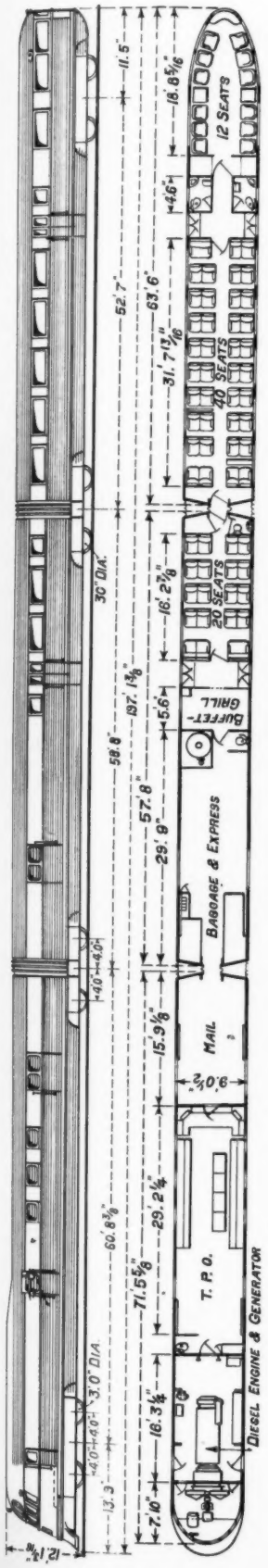


Diagram and seating arrangement of the 600 b.h.p. diesel-electric train, the Burlington Zephyr

are designed more as a means of attachment for auxiliary apparatus, and to stabilise the floor beams.

Each articulation casting is tied into the car frame structure by riveting to the centre members, to the end posts, and to the lower chords and vertical members of the stainless-steel end frames. Otherwise no rivets are used in the structure. Through this rigid end frame the reaction from the weight on the articulation pivot is transferred to the main side frames. Unlike the previous diesel and distillate-engined cars built by the Budd Company, the sheathing of the Zephyr is not all of the fluted type, in order to prevent the formation of shear lines which would probably develop in sheets only 0·02 in. thick. The walls and roof of the train are insulated throughout with Alfol, which is made up of several sheets of crinkled aluminium foil weighing about ¼ oz. per sq. ft. The car side panels are lined inside with Masonite, but the baggage rooms are finished with galvanised sheets.

Vestibule passages between the car bodies are enclosed by diaphragms bolted to the ends of the cars, and, like the doors, form an unbroken surface with the outside panelling of the car. The high speed of the car and the large window area called for a stronger glass than usual, and the material eventually chosen was 15 per cent. lighter and a good deal stronger than the standard plate glass. Because of the possibility of weaving being set up in the coach bodywork a special method of setting the glass had to be evolved in order to prevent any strain being thrown on the window glass.

Steam heating is provided throughout the train with steam furnished by an automatically-controlled oil-fired boiler with a capacity of 500 lb. of steam an hour at a pressure of 85 lb. per sq. in. The boiler is located at the rear end of the baggage room in the second car. A gilled-tube steam coil in the evaporator unit of the air conditioner supplies heat to the fresh and re-circulated air passing through the car, and steam is also led through a copper gilled tube along the floor on each side of the car. The compressors, condenser, and evaporator units for the air-

Front end view of the Zephyr

conditioning are all located below the floor of the coach, and supported by the bottom members of the framing. The evaporators deliver the air through grilles above the doors in the end panels. Re-circulated air leaves the compartments through filter protected openings in the floor above the evaporators. Celotex insulation is used for lining the whole of the air ducts in the train. The compressors and condenser of the air-conditioning equipment are driven by electric motors, and the plant as a whole was designed with light weight as a major objective. Including motors and controls, refrigeration and water lines, and electric cables the complete air-conditioning equipment scales only 1·3 tons.

Interior Fittings

The interiors of the passenger compartments are finished in pastel shades without striping, and the only ornamentation consists of highly-polished stainless steel window frames, and a band of similar material along the ceiling

at the open side of each lighting duct. In the smoking compartment the seats are upholstered in brown leather, and in the non-smoking compartment with low-pile mohair. The seats themselves are built up on aluminium alloy frames, and the backs are adjustable from the normal upright to a semi-reclining position. They have a clear space of 18 in. underneath for the stowage of hand baggage, and as further luggage space has been provided on each side of the short passage at the front end of the rear car, and also at the front end of the lounge, it has been found possible to eliminate the conventional overhead racks, and thus improve the appearance by preserving the motif of unbroken surfaces. A buffet, situated near the centre of the train, is equipped to supply a grill service and provide hot and cold drinks.

The engine room with the roof and radiators removed

All four bogies run on Timken roller bearings located outside the cast steel frames. The driving truck at the front end runs on 36-in. wheels, and the remainder on 30-in. wheels. Extensive use of rubber has been made in the construction of the bogies in order to prevent the transmission of noise and high-frequency vibrations to the car bodies. There are inserts under the pivot, between the ends of the compensating beams and the axleboxes, and on the pedestals. Rubber thimbles are also provided round the centre pin and the pivot bolts. A further precaution against noise is the provision of a Ferodo type of lining on those portions of the bogie frame structure against which brake rods might rub when passing round curves.

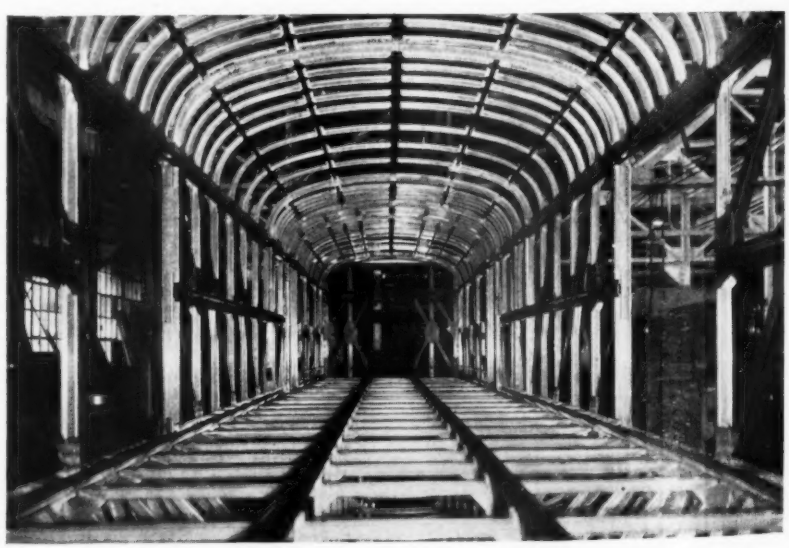
Brakes

A special type of Westinghouse brake, embodying both straight and automatic equipment, has been developed for this high-speed articulated unit. The automatic feature has been incorporated in case it should be necessary or desirable to move the train in connection with steam-worked stock. The brake valve is self-lapping, the degree of service application varying directly with the position of the handle. The dead-man control is operated either pneumatically by a foot pedal or electro-pneumatically by a push-button on the driver's brake valve handle. The release of both these automatically cuts off the power and causes an emergency application of the brakes. The brake valves also provide, electro-pneumatically, for an emergency application of the brakes should a failure of pressure in the straight-air pipe prevent a response to a movement of the brake valve to the service application position within a certain predetermined time interval.

To obtain the high rates of retardation necessary to keep the stopping distances from a speed of 100 m.p.h. within the present signal limits, the brake system is designed for a 200 per cent. braking ratio at a cylinder pressure of 100 lb. per sq. in. Because of the varying coefficient of friction between the brake blocks and tyres when speed is reduced, the brake cylinder pressure is controlled automatically, as the train slows down, by a retardation controller, a pendulum inertia device by means of which the pressure is reduced at a rate sufficient to maintain constant braking effect. This controller is wired in the battery circuit to solenoids on the control valves.

Power Plant

The power plant for driving the train consists of an eight-cylinder two-stroke diesel engine built by the Winton Engine Corporation, a subsidiary of the General Motors Corporation. The cylinders have a bore of 8·0 in. and a stroke of 10·0 in., and develop a total rated output of 600 b.h.p. at 750 r.p.m. The power is thus less than that of the European streamlined trains such as the Flying Hamburger and the 40 Dutch units, and amounts to 6·9 b.h.p. per ton of tare weight. Embodied in the engine are several novel features, including a welded steel piece which comprises the crankcase and cylinder block, and has been largely responsible for the reduction in engine weight to 22 lb. per b.h.p. The nine-bearing crankshaft is carried on main bearing seats fastened to the end of individual cross members cut to form frames for the welded engine blocks. By this means the combustion stresses are



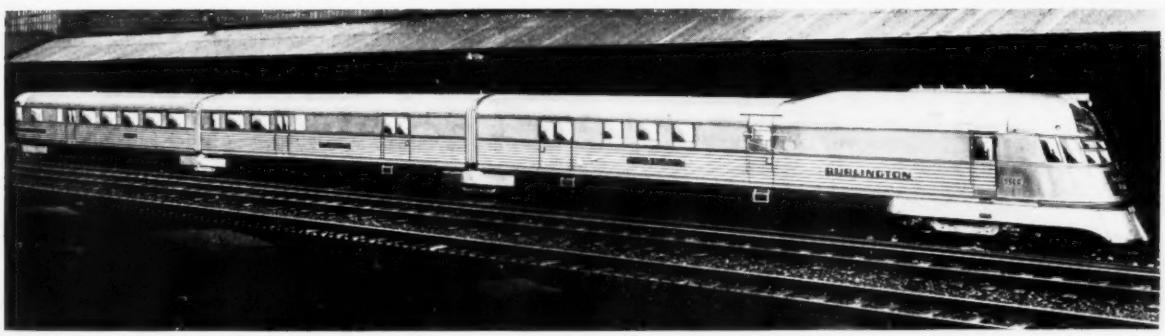
The shot-welded steel frame of the baggage car of the Burlington Zephyr

transmitted directly to the bearing seats through solid frames held rigidly by the various members of the welded block, which members incidentally form the air-intake passages, top and bottom of the cylinder block, and cross ribbing. The main and big-end bearings are lined with lead-bronze.

Water-jacketed liners of heat-treated cast iron are secured to the cylinder heads. Midway down the liners are 24 oblique air-intake ports circling the liners, and the cylinder block thus forms an air intake manifold in which pressure is maintained by a three-lobed twin-rotor scavenging blower mounted on the front-end of the engine block. Oil-cooling has been adopted for the crowns of the aluminium alloy pistons, the oil being forced up the connecting-rods. Special designs for the cooling and exhaust equipment had to be evolved in order to keep within the bounds of the streamlined contour. To accomplish this the silencer was lowered into a drop section in the car roof and the usual American gilled-tube roof radiators were re-grouped to form two long sections suspended from the inside of the engine room roof. Two large engine-driven fans are mounted above the partition separating the engine room from the control cabin. A grilled opening in the front of the train admits air to the fans through a duct formed by the car roof and ceiling. The large volume of air brought into the engine room passes through the cooling water radiators and thence outside through a central longitudinal slot in the roof, this ensuring the minimum disturbance of the air stream at the front end of the train.

A flexible steel-disc coupling is employed between the diesel engine and the main generator. A directly-driven auxiliary generator excites the main generator fields, and gives characteristics which permit of utilisation of the full engine power over a wide range of road speed. The exciter is of 25 kw. capacity, and the output is sufficient to furnish power to the compressor motors, air-circulating equipment, battery charging lights, buffet, &c. The two series-wound traction motors on the front truck are self-ventilated by fans mounted on the pinion end of the armature shaft, which is itself mounted on S.K.F. roller bearings, with axle bearings of the sleeve type. Ventilating air is taken from the engine room through canvas ducts. The motors are progressively connected in series, parallel, and paralleled with shunted field.

Engine starting is effected electrically, current being drawn from an Exide Ironclad battery of 32 cells with an amp. hr. capacity of 450, which is placed in a stainless steel box located in the engine room. Ventilating scoops are used to increase the air circulation through the battery container. The control apparatus consists of a master controller, electro-pneumatically operated motor contactors and reverser, and the necessary auxiliary magnetic contactors, switches and relays. The control provides for operation from the front end of the train only, and this also applies to the starting and stopping of the engine and the regulation of the head and interior lights. The current supplied from the exciter to the auxiliaries is regulated in such a manner as to give constant voltage regardless of the load, and over the full range of the engine from idling to the rated value. This has been made possible by the combined effect of the excitation and the use of a new dynamic relay.



The stainless steel Burlington Zephyr which is to go into 60 m.p.h. service on the Chicago, Burlington & Quincey Railroad

Important British Oil Engine Agreement

Arrangements have just been made between the Associated Equipment Company, of Southall, and the Soc. Ital. Ernesto Breda, of Milan, whose British representative is Mr. W. W. Adam, of 28, Guildford Place, London, W.C.2, for the manufacture of A.E.C. oil engines in Italy. The agreement covers the whole range of A.E.C. diesel products, and Ernesto Breda has just received an order for 20 diesel-mechanical double-bogie railcars from the Italian State Railways, which are to be fitted with 130 b.h.p. Breda-A.E.C. engines. Some of these cars will be powered by two engines, and will have Vulcan-Sinclair hydraulic couplings. The adoption of the diesel engine in preference to the petrol type is largely the result of the accident to a petrol car in Italy a few weeks ago, when a number of persons were burned to death through the petrol catching fire. We commented on this accident at the time.

French Diesel Railcar Working

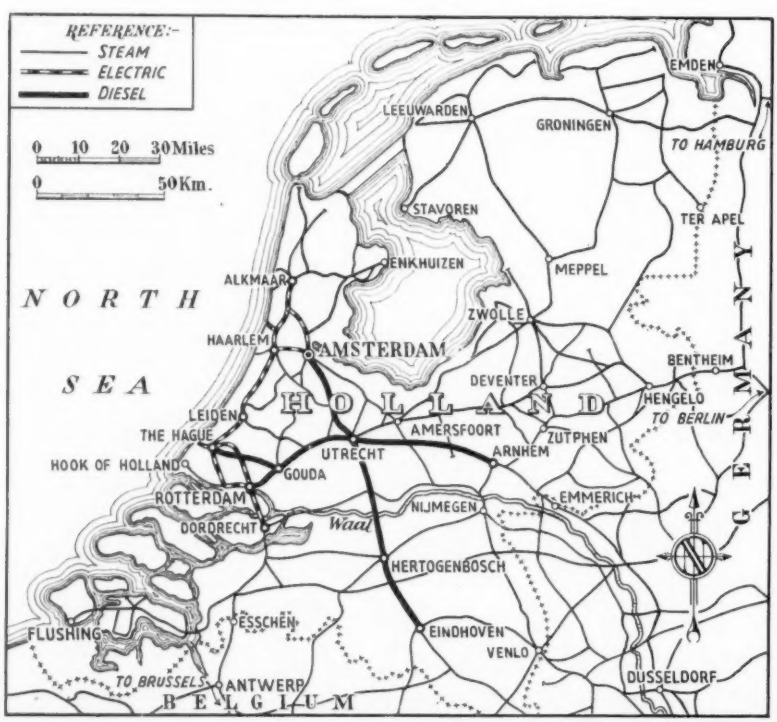
In order to get maximum service with minimum attention out of their diesel railcars, and at the same time offer the greatest possible facilities to travellers, several of the French railways have organised " stars " or groups of secondary lines radiating from some important town. For instance, the " Etoile de Compiégne " (Star of Compiégne) is a group of lines on the Northern of France Railway which radiate from Compiégne, and comprise the Compiégne-Soissons, Compiégne-Villers-Cotterets, Compiégne-Estrées-St. Denis, Clermont-de l'Oise-Beauvais, and Compiégne-Roye (Somme) lines. Other comprehensive star systems are the Mont de Marsan on the Midi Railway, the Le Blanc and Fontenay le Comte on the P.O., and the Mortagne on the Etat, all of which permit the operating staff to be grouped to greatest advantage and enable maintenance and repairs to be carried out with greater efficacy.

FORTY DIESEL TRAINS FOR HOLLAND

Intensive passenger service over 175 route miles commenced with the inauguration of summer time-tables on May 15

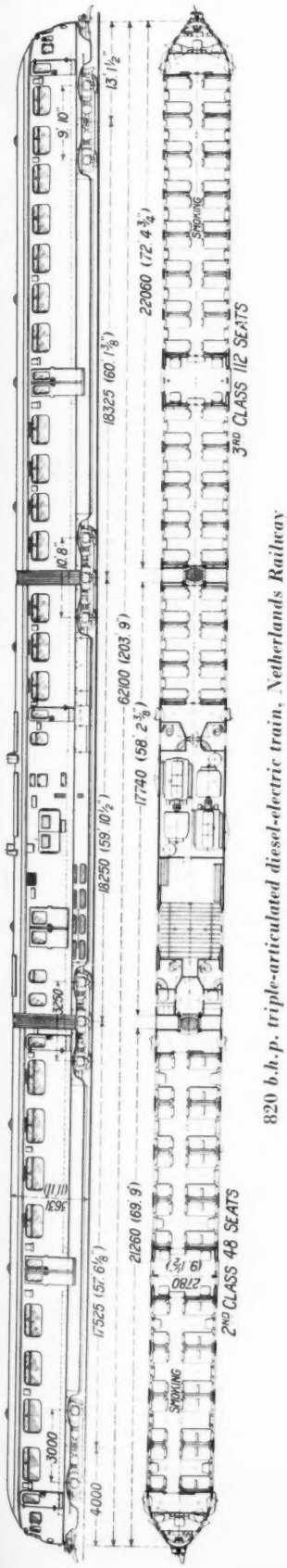
Four "Flying Dutchmen" ready for service at Utrecht

THE important era in the history of diesel traction, which began last Tuesday with the inauguration of a service of high-speed streamlined diesel-electric trains over 175 route miles of the Netherlands Railways, was the direct result of the fall in passenger receipts. So serious was the situation that at the beginning of 1933 the Board of Directors gave instructions for a large number of diesel vehicles to be constructed, and the primary condition insisted upon was that the stock should be ready for the commencement of the summer service on May 15, 1934. It was therefore no easy task which faced Mr. W. Hupkes, the Superintendent of Rolling Stock and Workshops, and his assistants, for in the space of 15 months it was necessary to get out the complete design, construct 40 trains, and carry out all the necessary preliminary tests. Matters were not made easier by the fact that the Netherlands Railways had previously operated only very small diesel vehicles, and the whole design had to be worked out without reference to first-hand past experience. This was probably one of the principal reasons why the Maybach engine was chosen, as much experience had been gained in Germany with these engines in diesel-electric vehicles, and not only were the various components of the engine and transmission fairly well standardised, but the designs and methods of construction of the bogie and body were capable of easy modification to suit the requirements of the Netherlands Railways. Moreover, the diesel engine was already in something approaching mass production at Friedrichshafen, and this was an important point, as time was short.



Map of Netherlands Railways, showing lines operated by diesel traction

Not unnaturally, it was desired to manufacture as much of the material as possible in Holland, and to that end the Werkspoor Company, N.V., took out a licence for the Maybach engine, and 20 engine units were constructed at Amsterdam; the remaining 60 were built at Friedrichshafen, but ten are being held in reserve, for five trains are being fitted with Stork-Ganz engines of 350-400 b.h.p. which were specially developed by Stork Bros., of Hengelo, who have been building Ganz engines since 1932. The Werkspoor company built 25 mechanical portions, J. J. Beijnes, N.V., of Haarlem,



820 b.h.p. triple-articulated diesel-electric train, Netherlands Railway

ten sets, and Allen, N.V., of Rotterdam, five sets, the last-named being those in which the Stork-Ganz engines are being installed. So far as the electrical equipment is concerned, 35 sets have been constructed to the designs and specifications of Brown-Boveri, two-thirds of this material being built under licence by Heemaj, N.V., of Hengelo, and the remaining third in the Baden and Munchenstein shops of Brown-Boveri. The five sets of electric transmission for the Stork-engine cars were supplied to Westinghouse designs by the Smit works, of Slikkerveer.

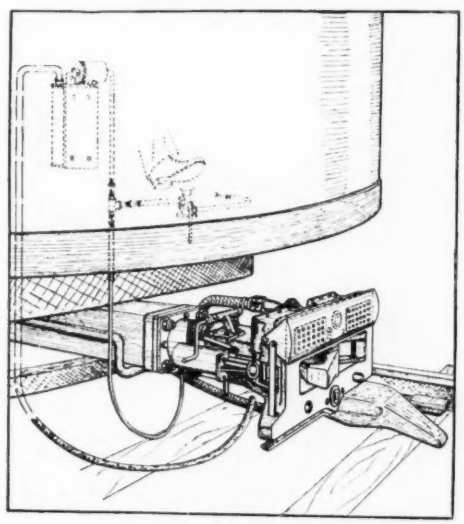
By the end of July, all the passenger services, except international trains, will be operated by these diesel trains coupled together in two sets of three cars, on the Amsterdam - Utrecht - Arnhem; Rotterdam-Utrecht; Utrecht - Eindhoven; and Gouda - Hague lines, the location of which are shown on the accompanying map. Since the first of the cars was completed about three months ago, intensive trials have been carried out with a view to obtaining reliable data as to the operating characteristics of the trains and training the drivers, most of whom are old steam men. Although under the present schedules the maximum speed does not exceed 62 m.p.h., the design was got out with a view to safe operation at speeds in excess of 90 m.p.h., and on a recent test run between Amsterdam and Arnhem a maximum rate of 90 m.p.h. was attained with a double-engine six-car set.

From the general arrangement drawing and illustrations presented with this article, it will be seen that these triple-articulated double-engined trains are streamlined in a similar manner to the Flying Hamburger of the German State Railway, and the contour of both types was determined as a result of wind-tunnel experiments carried out at the Zeppelin works, Friedrichsehafen. The main difference compared with the Flying Hamburger is that an extra coach body has been introduced to carry the two power sets, as the Netherlands engineers were not enamoured of the method of mounting the diesel engine and main generator directly on the bogies. The two power plants are situated side by side in the centre car; the end bogies are simply carrying units, and each of the six-wheeled articulation bogies carries two nose-suspended electric traction motors.

The tare weight of a complete six-car train is approximately 178 tons, or 204 tons with supplies and a full complement of passengers. The resulting value of 1,240 lb. per cent. is to some extent affected by the two classes of accommodation provided. The 9·2 b.h.p. per ton of tare weight permits of rapid acceleration, and trials have shown that on the level a speed of 59 m.p.h. can be easily attained in two minutes, and 75 m.p.h. in 4½ minutes. With a head wind of 6½ m.p.h., a speed of 81 m.p.h. can be maintained on the level, 59 m.p.h. up a grade of 1 in 100, 40 m.p.h. up 1 in 50.

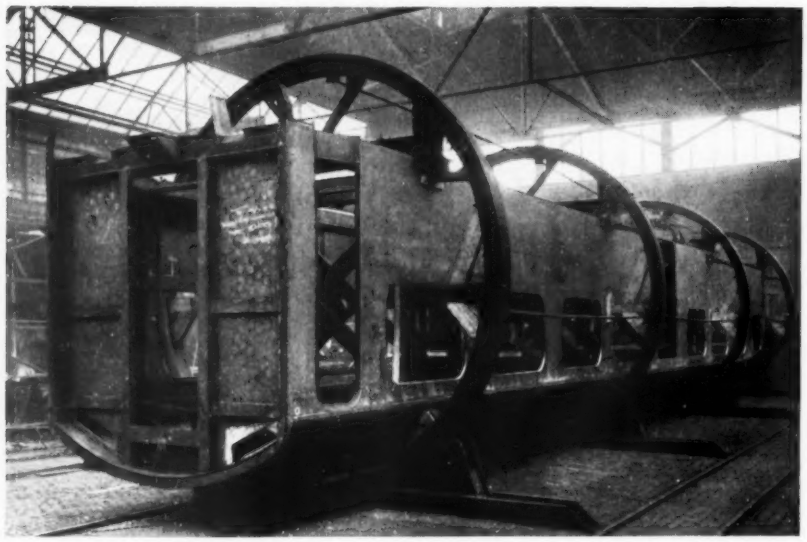
Car Bodies

With a view to saving weight, the carriage bodies have been fabricated by the electric welding of light sections and tubes. There is no separate underframe, but the bottom,



Special type of multi-purpose coupling used on Netherlands diesel-electric trains

sides, and roof are built together as one unit, and thus all elements contribute to the strength of the coach, giving minimum total weight and great safety for the passengers in case of accidents. The Netherlands Railways for some years made a careful study of electric welding, and the methods applied to the present cars are a development of those used in the construction of the main-line coaches described in THE RAILWAY GAZETTE for April 21, 1933. At the Werkspoor factory the framing was first erected on jigs and clamped for convenient welding in such a manner as to eliminate the necessity for subsequent movement and handling. In assembling the side members and panels, a squirrel-cage frame mounted on rollers was employed, and

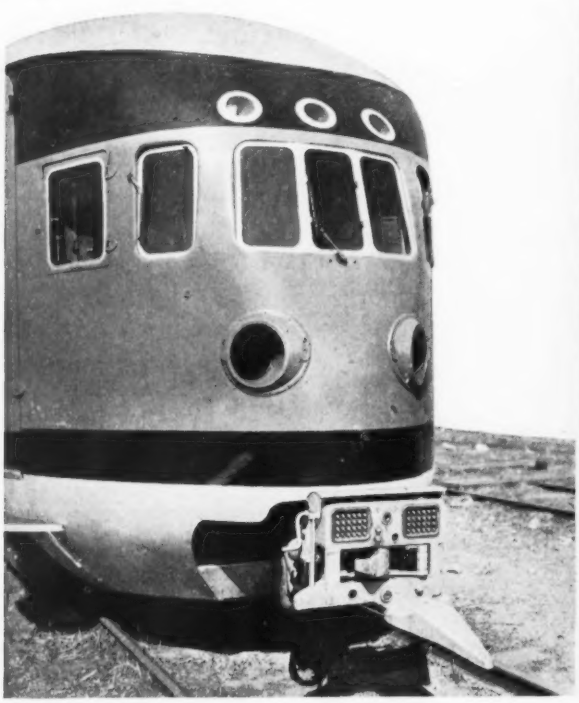


Body of diesel-electric train under construction at the Werkspoor factory. The circular frames are used to hold the body rigidly and rotate it during welding operations

every part of the car body was thus easily accessible to the welders as the whole unit was revolved. This method of construction is shown in one of the accompanying illustrations.

A further reduction in weight has been obtained by the use of aluminium alloys for the doors, and for such details as the luggage racks and end frames, reservoirs, air ducts, and fuel tanks. The flooring of all the cars is of Sorbo, cemented directly to the steel framing. This material, in addition to possessing non-slip and non-stretch characteristics, has the advantage that it can be flushed with water without deleterious effect. The end panels of the cars have steel frames covered with plywood and insulated with Cellotex, and the noise and heat-resisting properties of the last-named material are further utilised in the side panels and between the roof and ceiling.

As may be seen from the drawing, seats are provided for 48 second-class and 112 third-class passengers in smoking and non-smoking compartments. Lavatory accommodation in each half of a three-car train, and part of the centre vehicle is devoted to the carriage of luggage. The second-class seats, which are included at an unusually comfortable angle, are fitted with springs and upholstered in plush; in the third-class compartments the seats are of latex rubber, covered with artificial leather, and supported on tubular frames of stainless steel. To minimise the transmission of noise and vibration from the engines, the doors at each end of the centre car are doubles. The passenger compartments have entrance and exit doors at the ends and in the middle, which are so marked that entraining passengers will use the centre doors while those alighting will make use of the end doors. On the Amsterdam-Rotterdam electric stock the principle of a constant flow of passengers

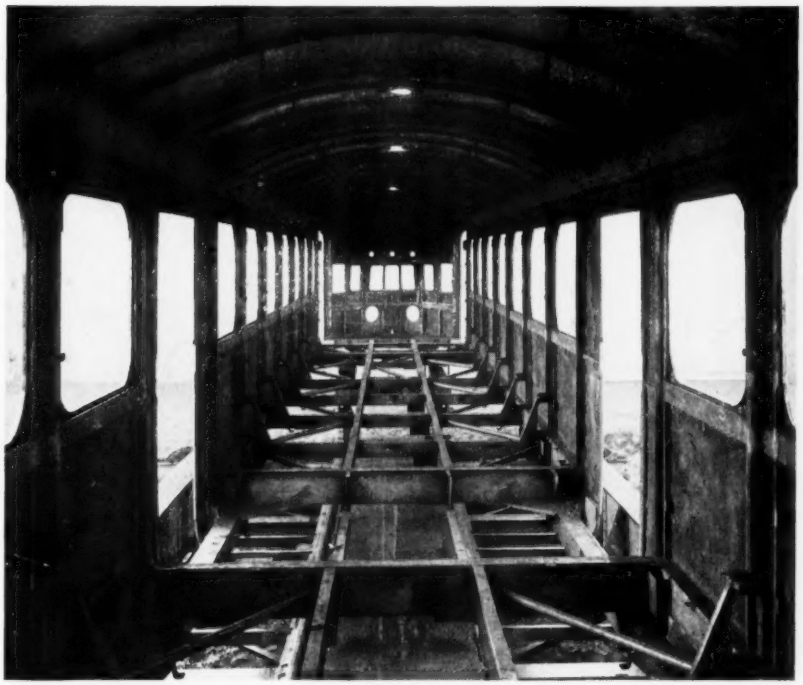


End view of car, showing Universal-Scharfenberg-Unirop couplers in open position

Driving position of diesel-electric streamlined trains of the Netherlands Railways

is realised by arranging their entry to each car at the rear and exit at the front.

Heating and ventilation of the passenger compartments have received very careful attention. The temperature in the carriages is regulated by thermostats, and heating is normally effected by circulating through the interior, air which has been raised in temperature by the engine cooling water in a special heater. The air is drawn in through filters and ducts situated just inside the articulation bellows, and blown into the passenger compartments by means of two compressors, each absorbing 2·2 kW. In cold weather this method of heating is supplemented by the circulation of hot water produced by an automatically-controlled oil-fired boiler, which is switched on or off by the action of thermostats. An electrically-driven pump circulates the water. In summer, when heating is unnecessary, the same quantity of air is circulated, but it is bye-passed from the air-heater. The upper portions of the windows are in the form of sliding lights, which permit of still further ventilation without any noticeable draught being directed on the seats.



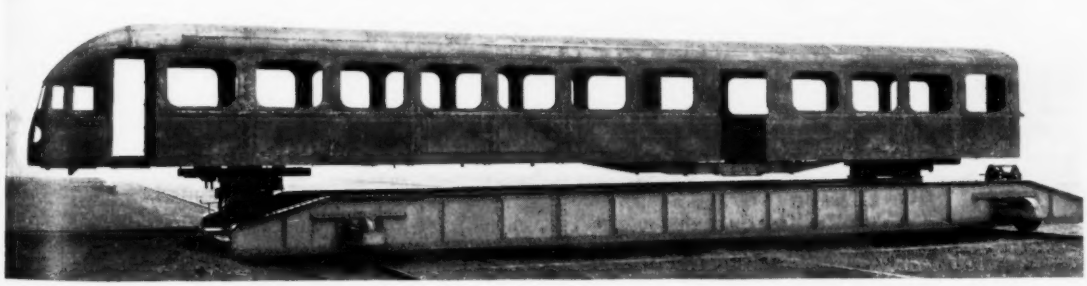
Body framing under construction at the Allan works, Rotterdam. Steel roof, sides and floor form one girder

Energy for the lighting and electric control is supplied from a small motor-generator set, with a voltage regulator fed from the battery, so that the starting of the main engine will have no effect on the lights or the control circuit. The 90-cell 200 amp. hr. battery is located beneath the floor of the centre car, and is of the Nife type, made by the Svenska Akkumulatoren A.B. Jungner. It is automatically kept charged from a special winding on the main generator.

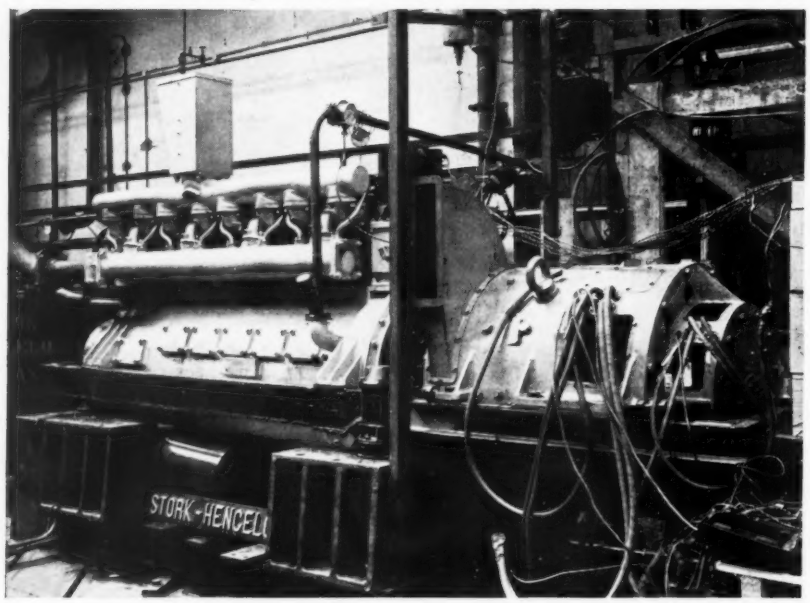
In order to couple or uncouple two sets of cars in the shortest possible time, automatic couplers of the Universal-Scharfenberg-Unirop type have been incorporated, and the features of the design may be picked-out from the two illustrations presented with this article. By a simple running together of the vehicles, the projecting arm of the coupling on one car runs up that of the other and presses back the cover of the coupling proper, and at one and the same moment enables the coupling of the drawbars, air-brake conduit, heater pipes, and electrical connections to be effected. Release is carried out by depressing a foot pedal in the driving compartment, and this action first puts out the mechanical coupling, then closes the air-brake line and heater pipes in the ends of the two units, and finally a pull switch disconnects the electric jumpers. As soon as the pedal is released, both units are ready to move off in their respective directions.

Knorr-Lambertsen air brakes are fitted, and the equipment permits of graduated application and release. It is claimed that even with a full application at the highest speeds, the action is smooth and free from shock. The normal type of railway brake has been given up in favour of the automobile drum pattern. Each road wheel has a drum with two Ferodo-lined shoes. One brake cylinder is provided for each shoe, but all the brake cylinders on any one bogie are served by a single triple valve and auxiliary reservoir. The maximum air pressure in the brake system is 100 lb. per sq. in., and the air is supplied by two electrically-driven compressors, which also provide the air for the horns and electro-pneumatic control.

The bogies are of light but strong welded steel



Completed body framework of one of the outer cars of the diesel electric trains belonging to the Netherlands Railways



Above.—One of the 820 b.h.p. diesel electric trains of the Netherlands Railways in the Werkspoor yard in Utrecht

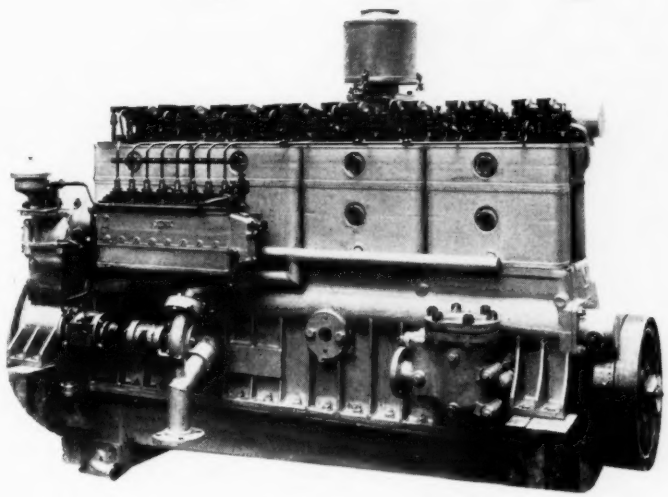
Left.—350–400 b.h.p. Stork - Ganz engine under test at the works of Stork Bros., Hengelo

Below.—Interior of second and third-class compartments of the 40 high-speed articulated electric trains just set to work on the Netherlands Railways

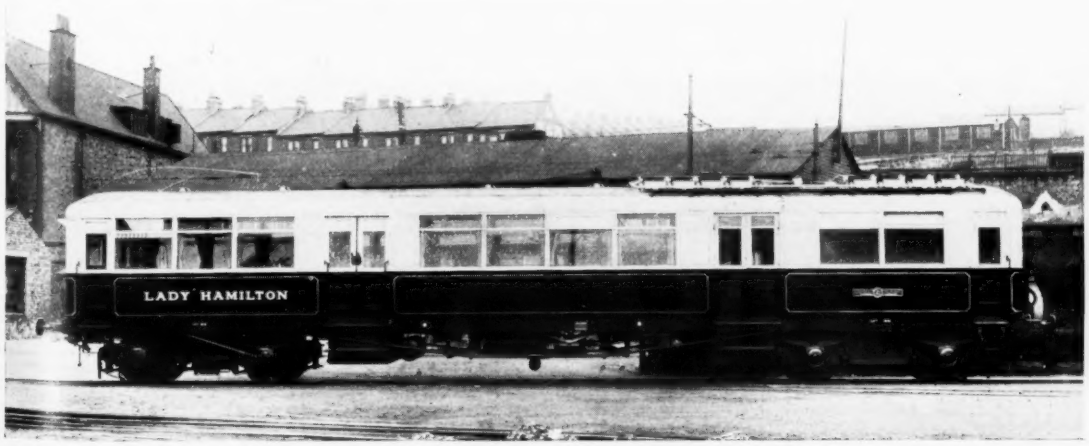
construction, and incorporate a number of standard carriage details. The wheels, of the Uerdingen disc type forced on hollow axles carried in S.K.F. and Timken roller bearings, are 36½ in. diameter; in the four-wheeled end bogies they are spread over a base of 9 ft. 10⅛ in., and in the six-wheeled motor bogies over a base of 10 ft. 8 in. When fully loaded the maximum axle load is 14 tons.

In the centre vehicle of each of the first 35 triple-articulated trains are mounted two 12-cylinder V-type Maybach diesel engines with directly-coupled generators. Within cylinders of 5·91 in. diameter and 7·9 in. stroke, 410 b.h.p. is developed at a rotational speed of 1,400 r.p.m. These engines scale slightly more than the original units fitted to the Flying Hamburger, the unit weight being 11 lb. per b.h.p. compared with 9·25 lb. The generator has a capacity of 235 kW. and a maximum voltage of 700. Each engine-generator set is supported on four rubber cushions and is completely enclosed in a casing of sheet aluminium lined inside with Celotex. Large removable doors in the side panels of the engine room allow of easy access to the power plant for maintenance or light repairs. No engineer or mechanic is carried in addition to the driver. In the last five trains a straight-eight Stork-Ganz engine is used, and as this develops 400 b.h.p. at 1,450 r.p.m., the characteristics of the main generator are slightly different from those driven by the Maybach engines at 1,400 r.p.m. One of the Stork-Ganz precombustion chamber engines is shown on the test bed in an accompanying illustration. The eight cylinders have a bore of 6·71 in. and a stroke of 8·7 in. In both types, each diesel engine has its own cooling system, with fan-cooled radiators placed below the luggage compartment. During the winter the cooling-water circuit is kept at a temperature of 60 deg. F., when the car is out of service, by means of the two thermostatically-controlled furnaces used for heating the passenger compartments.

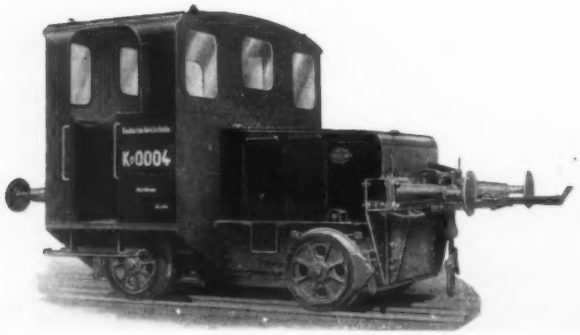
Driving cabins are arranged at both ends of a three-car set, and any number of sets may be driven by one man from a single position. One of our illustrations gives a view of the driving position; the left hand of the two meters directly in front of the driver's seat is the revolution counter with a scale for each of the four engines, and by its side is a similar gauge for the cooling water temperature. The valve and piping immediately below the centre window is the apparatus for the air-operated window-wiper. To the left is the main controller handle with a dead-man attachment, and past this on the far wall is the voltmeter for the lighting circuit. The start and stop buttons for the four engines are located at the extreme right-hand of the dashboard, with the driver's brake valve immediately in front and the air brake gauges and speed indicator just above. Below the centre of the dashboard is the pedal for operating the automatic coupler. The speed regulator of the engines is electrically-controlled, and governs the fuel supply and stops the engine if the lubricating oil supply fails.



Fuel pump side of 350-400 b.h.p. Stork-Ganz engine as used on the last five of the Netherlands Railways diesel trains



250-b.h.p. Armstrong-Whitworth railcar just delivered to the L.N.E.R.



Left.—25 b.h.p. two-stroke diesel-mechanical loco-tractor, German State Railway
Right.—Frichs four-stroke diesel-mechanical loco-tractor, Danish State Railways

Right.—15-ton 95 b.h.p. diesel-electric shunting locomotive, built by Armstrong-Whitworth, at work at a Scunthorpe steel works. This locomotive was shown at the Shipping and Machinery Exhibition at Olympia in 1933, and has since been tried out in heavy shunting service at various establishments

Krupp 600 b.h.p. diesel-mechanical locomotive engaged in goods service on the lines of the Japanese Government Railways

160 B.H.P. SHUNTING LOCOMOTIVE, L.M.S.R.

The fifth locomotive of an order for nine has been completed at Preston

OF the nine diesel shunting locomotives ordered by the L.M.S.R. last year, the unit by the Drewry Car Co. Ltd. has now been completed, and during last week it was put through some preliminary tests at Preston Docks, adjacent to the Dick Kerr works of the English Electric Co. Ltd., where it was built.

This locomotive, which is of the four-wheeled type, and scales 26 tons, was found capable of handling 400-ton trains in first, second, and third gears, while sufficient speed was attained in the second step for fly shunting with trains of 200 tons.

Built by W. H. Allen, Sons & Co. Ltd., the engine is of the straight eight four-stroke type, with a Bosch fuel pump for each cylinder and open combustion chambers. Two inlet and two exhaust valves are provided for each cylinder, and these are operated through short push rods by a chain-driven camshaft placed rather high up alongside the cylinders. This arrangement of the valve gear greatly facilitates inspection, since advantage has been taken of it to provide a crankcase having the whole of one side removable. The pistons, which have concave tops, are of iron (though the makers supply aluminium pistons for engines to be run at high speeds), and the cylinders are in the form of centrifugally-cast nitrogen-hardened liners.

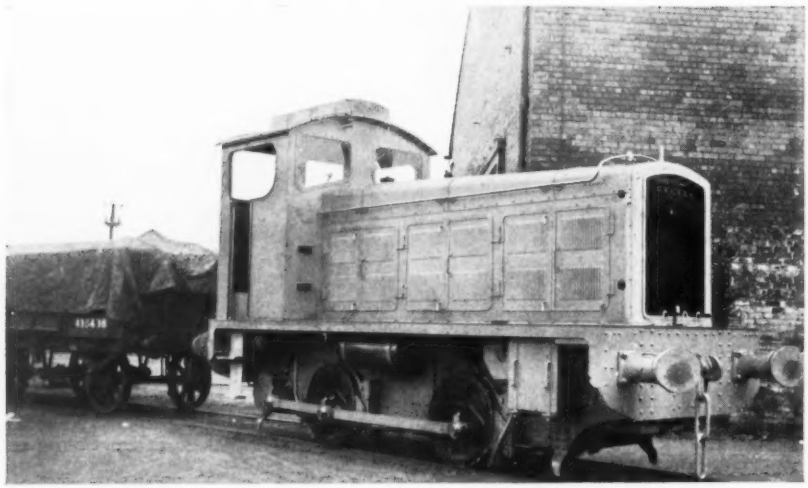
A 24-volt 200 amp. hr. C.A.V. storage battery provides the energy for starting, and this is charged by a C.A.V.-Bosch dynamo driven from the front end of the engine. The radiator, which is in front of the locomotive, is of Serck construction, and there is a section in it devoted to lubricating oil cooling. The fan is driven by a V belt. Fuel is supplied through twin filters, either of which can be cleaned with the engine running. The overload capacity of the engine at 1,200 r.p.m. is 182 b.h.p. and this can be sustained for two hours.

The engine is provided with a Vulcan-Sinclair traction type coupling and the drive from this is taken through a four-speed Wilson-Drewry epicyclic gearbox incorporating the usual camshaft for gear preselection. The busbar is depressed by an air cylinder and its release for gear engagement takes place gradually, independently of anything the driver may do. The final drive to the jackshaft is via helical gears, and enveloping type worm reduction of Bostock & Bramley manufacture.

Slight misalignments in the drive between engine and gearbox are accommodated by Hardy-Spicer couplings, and on the output side of the box a Standage coupling is provided. Torsional flexibility is afforded by the fluid coupling which enables gears to be preselected and engaged with the locomotive held stationary by the brakes or by a heavy train, and with the engine idling. The overall ratios afforded by the transmission are 50·5, 28·0, 16·75 and 10·0 to 1, while the corresponding tractive efforts are 11,200, 8,570, 5,050, and 3,500 lb. The speed ranges in m.p.h. are 0—2·9, 2·9—5·1 5·1—8·5 and 8·5—12. The above speed figures are for normal duty with relatively heavy trains. The locomotive by itself can be started easily in any gear, and light trains can be started without resorting to first speed. The air compressors, which are of Westinghouse manufacture, are driven by chains from sprockets behind the fluid coupling.

A Watford electric revolution counter and a Harding tachometer, giving both the train speed in m.p.h. and the locomotive mileage, are provided in the right-hand corner of the cab. In the left-hand corner are the air and lubricating oil pressure gauges. Red warning lamps are provided on each side of the cab to indicate when the lubricating oil pressure is insufficient. These are alight when the engine is first started, but if all is in order the

L.M.S.R. four-wheeled shunting locomotive with 160 b.h.p. Allen engine hauling test train at Preston docks



The latest diesel-mechanical shunting locomotive on the L.M.S.R.

oil pressure quickly builds up and they go out. The regulator is duplicated so that the driver can control the engine speed while leaning out of the cab on either side. Duplicated also are the controls for reversing, for gear preselection, and for busbar or clutch actuation. From the cab centre to right and left they are in the order given and all are in the form of short levers, moved by the driver towards or away from himself. The near or backward positions correspond to reverse in the final drive, neutral in the gearbox, and a depressed busbar. The forward positions correspond to forward in the final drive, top ratio in the gearbox, and a tightened band brake or clutch. Below these controls to the left is a short upright lever which can be turned to the right for relieving engine combustion. To the right of this lever is the switch board, with main switch engine starter button, and cab light switch. A battery charging current ammeter is also provided.

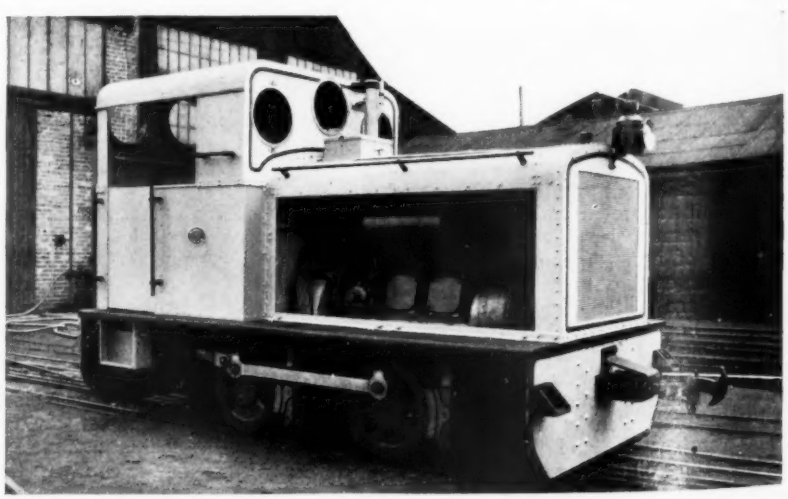
The air whistle is actuated by pulling on one side or the other of a round leather belt forming a V near the cab roof. Fuel is replenished through a filler projecting from the hood in front of the cab, but a glass fuel level indicator is provided inside the cab. The sandboxes are beneath the cab, and are replenished through openings on each side, a few inches from the floor. Like all units having the Wilson-Drewry transmission, the new locomotive can be handled with ease after a few minutes' instruction, and given time for a little practice, any driver should be able to perform his duties in the shunting yard efficiently and safely. Very much to the advantage of the Wilson-Drewry transmission in shunting work is the quickness and infallibility of the gear change. Snatching when hauling and separation from the train when pushing cannot occur to a troublesome extent where the breaks in the acceleration period are of very short duration, and a Wilson-Drewry equipped locomotive is thus eminently suited to the onerous conditions of shunting service.

TWO BRITISH-BUILT DIESEL LOCOMOTIVES FOR INDIA

Light-duty units with two-stroke engines

TWO small diesel-mechanical locomotives embodying features of some interest have just been constructed by W. G. Bagnall Limited, of Stafford, the first to the order of the Assam Railways and Trading Co. Ltd. and the second to the order of the Budla Beta tea gardens, which are also situated in Assam. These locomotives are the first examples built in Britain which are powered by Deutz diesel engines, for which W. G. Bagnall Limited is the British licencee, and both were constructed to the requirements of Messrs. Robert White & Partners, Consulting Engineers, London.

The larger locomotive is for service on metre-gauge lines, and is driven by a two-cylinder two-stroke Bagnall-Deutz engine with directly-driven scavenging pumps, which draw in air through filters. Each cylinder has a fuel pump of its own, regulated by a precision centrifugal governor, so that they supply just as much fuel for each stroke as is required by the momentary load. The engine cooling-water is circulated by an engine-driven centrifugal pump through gilled-tube radiators supplied by the Spiral Tube & Components Company, of Derby. The radiator elements are similar to those provided on some of the

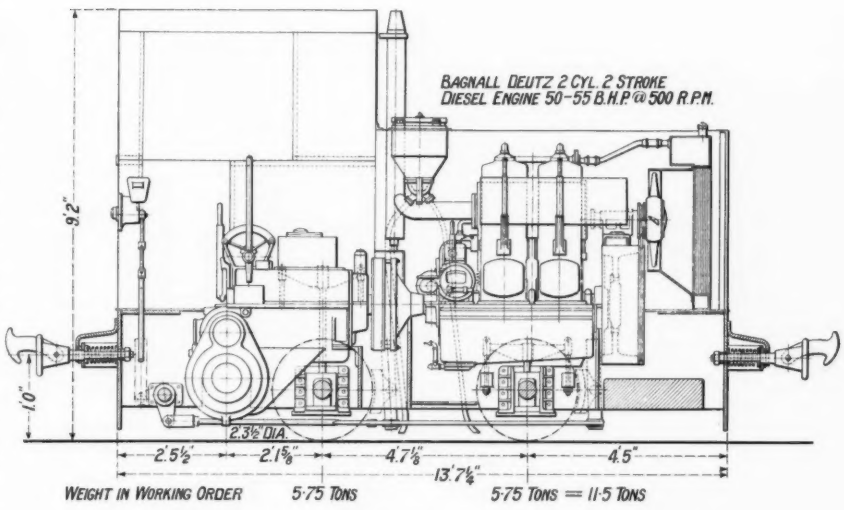


50-55 *b.h.p. diesel-mechanical locomotive for the Assam Railways powered by two-stroke engine*

L.M.S.R. shunting locomotives. The engine is started by compressed air, which is produced by passing part of the exhaust gases through a non-return valve into the air bottles. During brief working pauses which are too short for the engine to be shut off, the normal speed of the engine, 500 r.p.m., can be reduced by about 50 per cent. by means of a special regulating device. The fuel tank has a capacity of 12 gal., sufficient for 12 hr. of normal service.

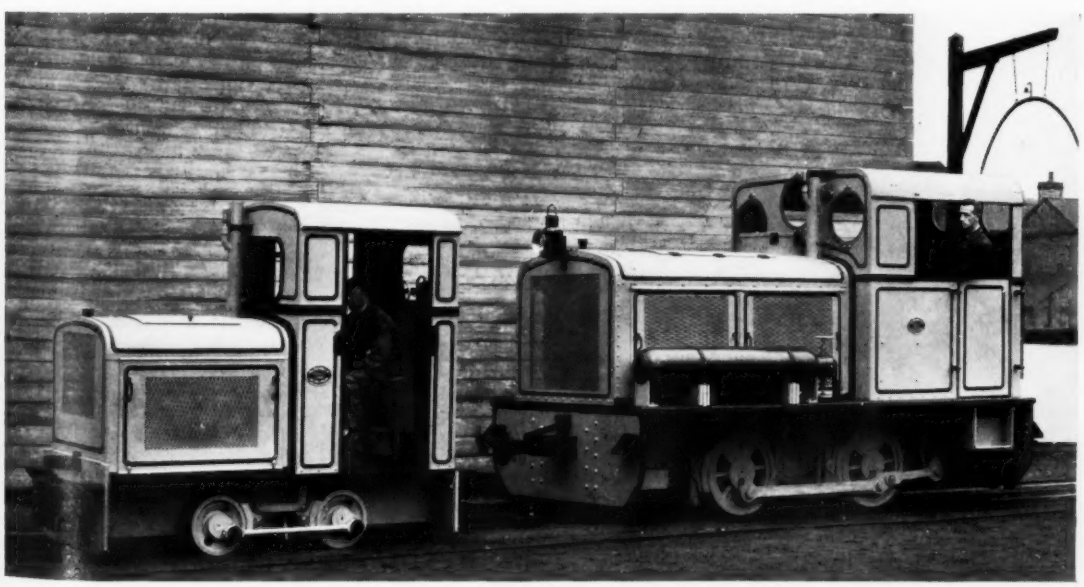
Both engine and gearbox are secured directly to the locomotive frames, and the engine torque is transmitted through a cardan shaft and friction clutch to the primary shaft of the gearbox. With normal engine speed, the road speeds are 3·0, 5·0, 7·75, and 12·5 m.p.h., and the gears are of the constant-mesh type, running in oil. The double-disc friction clutch is actuated through oil pressure applied by a hand-operated slide valve, and the slippage can be varied over a wide degree. Through the effective cooling provided, the clutch permits of an exceptionally long slipping period, and this, together with the wide range of engine speed, results in smooth starting and gear-changing. On the different gear steps corresponding to the road speeds given above, the tractive efforts at full engine output are respectively 4,840, 2,904, 1,628 and 858 lb., giving an adhesion factor of 5·3 on the lowest step, which enables a load of approximately 260 tons to be started on level track.

All parts of the gear mechanism run in roller bearings, and the gear wheels are of case-hardened steel. The speed gears are actuated by a link-system, and the direction of running is reversed by a simple hand lever. From the jackshaft, the wheels are driven through driving and coupling rods, and all the control levers are arranged in convenient positions in the cab. The leading particulars of the locomotive are shown on the accompanying drawing.



General arrangement of 50-55 b.h.p. diesel-mechanical locomotive

A two-cylinder two-stroke Bagnall-Deutz diesel engine is also fitted to the smaller locomotive, but in this case the rotational speed is 700 r.p.m., and the cylinders 7 in. dia. by 10 in. stroke. The output is 22-24 b.h.p., and the fuel consumption in normal service averages about 5·5 lb. per hour. The engine circulating water is cooled in a radiator of the Spiral Tube & Component Company's manufacture. This locomotive, which is shown alongside the larger model in one of the accompanying illustrations, has a weight of 4·5 tons, wheels of 16 in. diameter, a wheelbase of 3 ft. $0\frac{5}{8}$ in., and an overall length of 10 ft. 2 in. The four gear steps correspond to road speeds of 1·87, 3·24, 5·42, and 9·68 m.p.h., the corresponding tractive efforts being 1,980, 1,980, 1,066, and 506 lb. A load of approximately 105 tons can be started on the level.

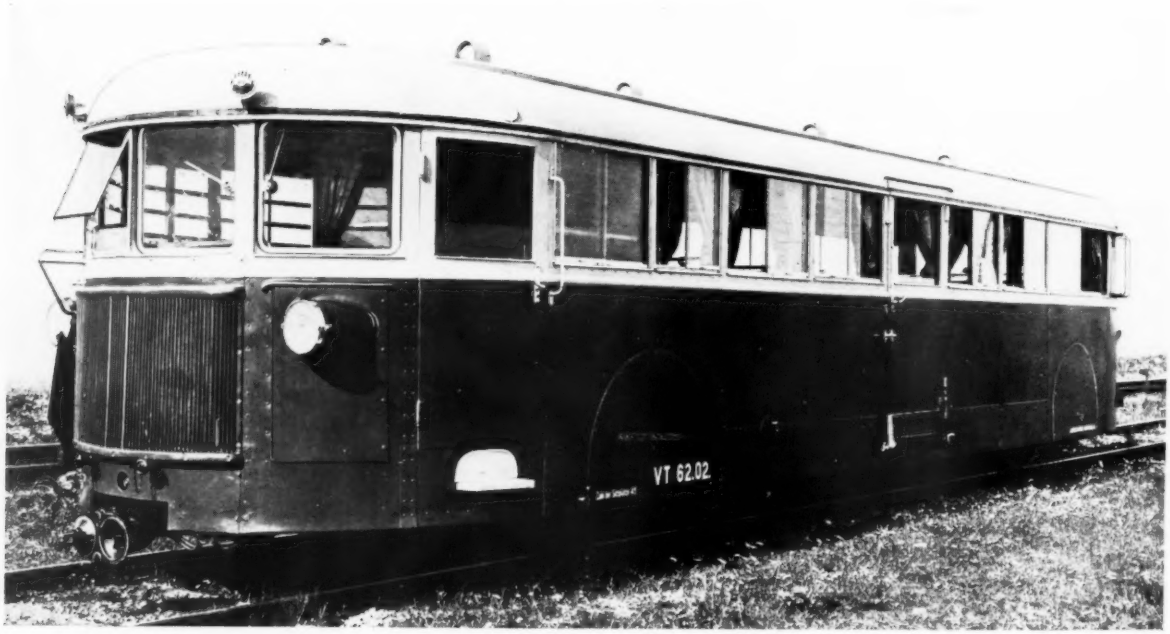


20-24 and 50-55 b.h.p. Bagnall diesel-mechanical locomotives for India

TRANSMISSIONS FOR DIESEL LOCOMOTIVES AND RAILCARS

The Voith-Sinclair Turbo-Converter

By STUART MIALL, B.Sc.



90 b.h.p. Austro-Daimler railcar of the type used on the Austrian Federal and Polish State Railways and fitted with the Voith-Sinclair type of turbo-converter

IN the *Diesel Railway Traction Supplement* for February 23, 1934, a new converter for diesel vehicles was introduced to readers of THE RAILWAY GAZETTE for the first time. Known as the Voith-Sinclair turbo-converter this drive differs in several respects from the alternative Lysholm-Smith drive. The engine shaft is coupled directly to the fluid impeller of the turbo-converter and not through a friction clutch, and the turbine runner, having no freewheel inside, rotates with the propeller shaft. Solid with the turbine runner, and hence with the propeller shaft, is one half of a Vulcan-Sinclair coupling or fluid flywheel, the other half of which is turned by the engine.

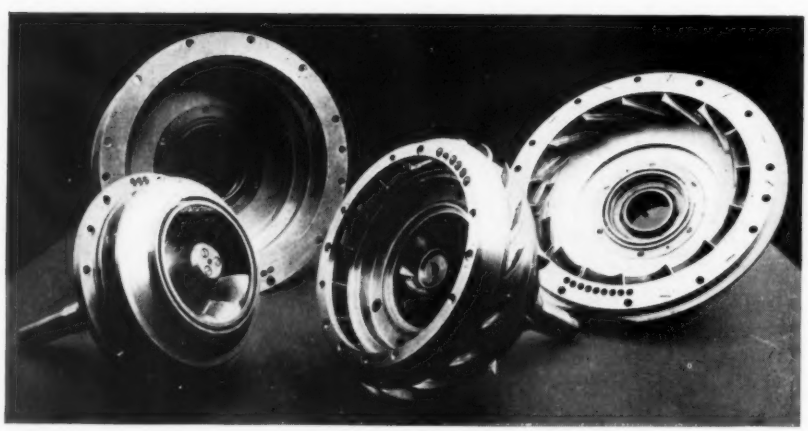


Fig. 1—Torque converter elements of Voith-Sinclair turbo-converter with two-stage turbine

The fluid coupling is functionless at starting, being without any liquid inside, and the drive from the engine to the propeller shaft is by way of the turbo-converter. Liquid is permitted to leak away from the converter all the time, but a small centrifugal pump geared to the driving shaft keeps it full as long as this is desired by restoring the leakage oil after it has passed round a cooling circuit. From the curves published in the February 23 issue, it can be seen that during the operation of the converter the torque multiplication varies between 4:5 to 1 at starting, and 1·1 to 1 at the highest normal working speed, when the runner has attained about 67 per cent. of the impeller speed. The efficiency meanwhile rises to a maximum of 85 per cent. when the torque conversion ratio of the order

of 2:1, this, as might be expected from turbine theory, occurs when the runner speed is about 50 per cent. of the impeller speed, and then falls to about 75 per cent. As the runner approaches the recommended speed of 67 per cent., the valve admitting fluid to the converter is closed by the driver and another is opened diverting the output from the centrifugal supply pump to the Vulcan-Sinclair coupling. Leakage from the converter causes it to empty quickly, but the drive is picked up by the filling of the coupling while the converter is still transmitting power. Like the converter, the coupling is provided with calibrated leakage ports so that it can be kept full only by continuing the supply from the pump. In its turn the coupling can be swiftly emptied by shutting off this supply.

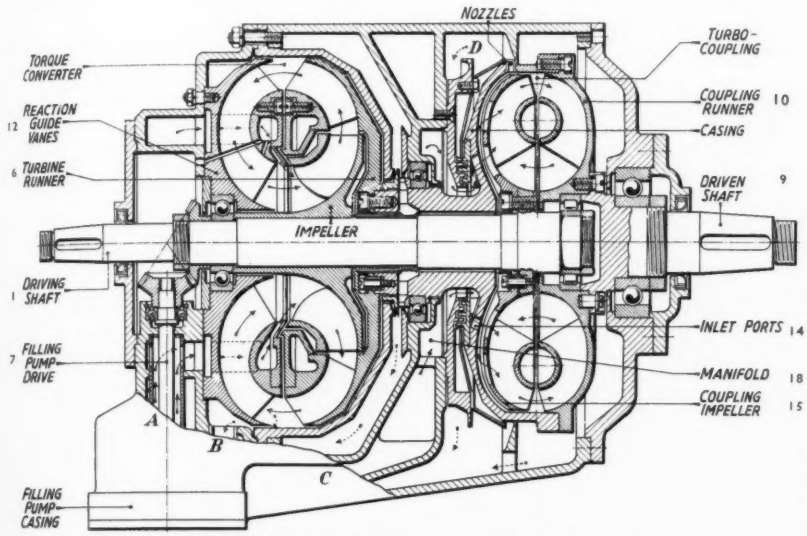


Fig. 2—Voith-Sinclair turbo-converter with single-stage turbine

With the coupling full and the converter empty, the torque transmission ratio is 1:1 and the efficiency rises as the coupling slip decreases, until, with a slip of about 1½ per cent., the efficiency is in the neighbourhood of 98·5 per cent. From this brief description it can be seen that churning losses in the inoperative converter are obviated by the simple expedient of cutting the converter out of the fluid circuit, and diverting the pump output through the coupling. When it is desired to coast with all connection interrupted between engine and propeller shaft, the suction to the pump is shut off.

Shockless Drive

The most conspicuous advantage of the Voith-Sinclair drive is that it gives the shockless fluid coupling drive after the torque converter has ceased to function. This is particularly important when the vehicle is passing rapidly over points and crossings, for as Mr. J. S. Tritton recently pointed out in his paper "Railcars," read before the Institution of Locomotive Engineers, the shock-absorbing pneumatic tyre, which safeguards the engine and transmission of the automobile, is lacking on the railway, and there is instead the somewhat harsh action between the unyielding steel wheel and steel track.

Experienced in the design of much larger hydraulic machines, the Voith Company of Heidenheim were satisfied that a relatively simple turbine unit would suffice for torque conversion work, and it will have been noticed that in the earlier design of turbo-converter illustrated in the issue of February 23 (Fig. 3), the turbine element had only two stages, *i.e.*, only two rings of moving blades. The essential parts of this two-stage converter are shown in Fig. 1 accompanying this article. The left-hand bladed member is the engine driven impeller which forms a mixed (axial and radial) flow centrifugal pump of a type made in much larger sizes for high efficiency pumping. The central bladed member is the turbine runner having two blade rings, while the right-hand bladed member is the stationary or reaction one. In the latest design of Voith-Sinclair turbo-converter a similar high efficiency impeller is used in conjunction with a turbine having only a single stage, *i.e.*, but one set of blades, and the diagrammatic view given in the previous description (Fig. 2) was meant to represent this later development. A more detailed sectional view of the single stage turbo-converter is given in Fig. 2 of this article. Here 5 and 15 are the two impellers rotated by the engine (coupled to 1), while 6 and 10 are the turbine and coupling runners respectively which turn the propeller shaft (coupled to 4). The paths of the fluid are shown by the arrows, but it is to be understood that circulation does not occur in the torque converter (left) and in the coupling (right) simultaneously: the liquid either goes in at A and out at B, or in at C and out at D, depending on whether he torque converter or the coupling is in action.

Some idea of the external appearance of the Voith-Sinclair unit is given by Fig. 3. Of the new single stage turbine units illustrated in Figs. 2 and 3, about 40 are now in service and under construction. Their capacities are 90, 210, 420 and 600 h.p.

Since the capacity of all hydraulic turbine devices increases very rapidly with the speed of rotation, it has been found advantageous in some instances to use a speeding-up gear between the engine and turbo-converter, so enabling the converter dimensions and first cost to be considerably decreased. Fig. 5 shows alternative designs brought out in this country in conjunction with Bostock & Bramley Limited, who are responsible for the gearing employed. On the left a unit having a single

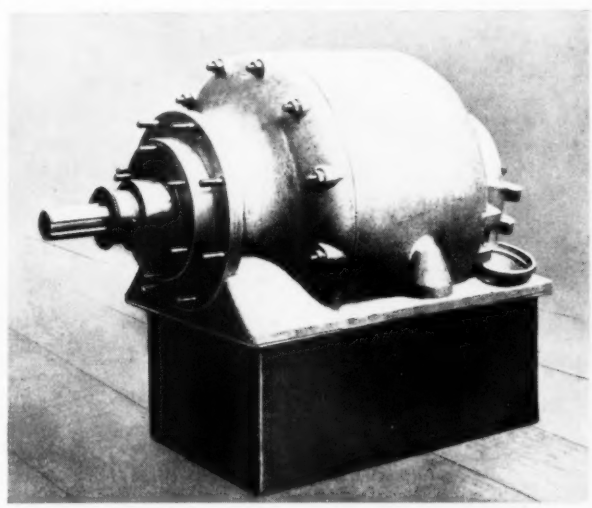


Fig. 3—External view of Voith-Sinclair turbo-converter for 90 b.h.p. railcar

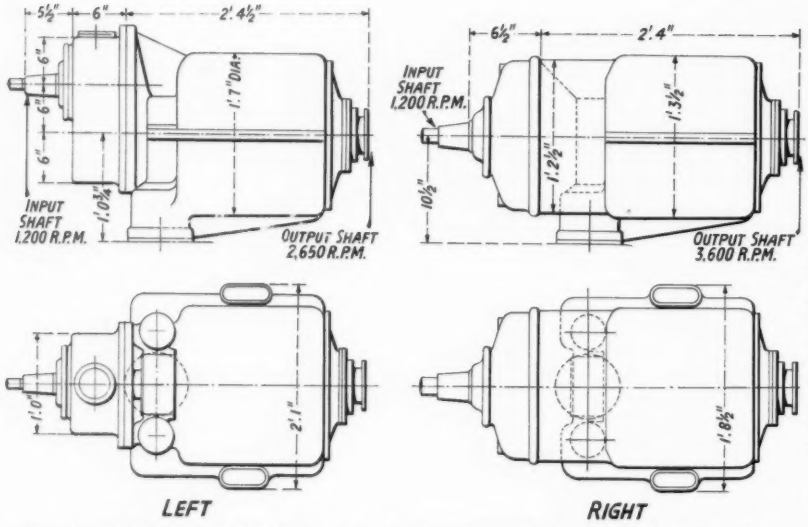


Fig. 4—150 b.h.p. Voith-Sinclair turbo-converters with overspeed gear drive

helical increasing gear is shown, while on the right is depicted a unit having an epicyclic train giving straight line transmission. Geared up units are connected directly to the engine, but a special flexible coupling is interposed to prevent any risk to the gears due to torsional vibrations of the engine crankshaft. The Voith-Maurer coupling shown in Fig. 5 is used for this purpose, flexibility being provided by dozens of looped wire springs of which two appear in the section. The flanged member is bolted to the engine flywheel and the inner member is keyed to the input shaft of the turbo-converter. The Voith-Maurer coupling is already widely used in industrial and marine applications, having been available in many sizes for more than two years. Its place can be taken if desired by a further hydraulic coupling, but as the converter itself gives sufficient protection from shocks coming from the driving wheel side, this may not be considered essential.

The most obvious field for the Voith-Sinclair turbo-converter is to railcars, particularly those of high power and speed, where the ease of arranging remote control favours either single or multiple unit operation. The torque converter element is only then in operation for a fraction of the time and the majority of the running is carried out with the turbo-coupling in action, so that the overall transmission efficiency is extremely high, being notably better than electric transmission under the same operating conditions.

Another field of application which may have useful scope in the future is to shunting locomotives, particularly those required for fly shunting, where the gear changing operation on a fluid-mechanical transmission involves the slackening of the train couplings at each gear change. In this case practically all the work must be done on the torque-converter element, but ample radiator capacity can be provided on locomotives of 100-250 b.h.p. to deal with the heat generated due to the repeated starting up of trains of wagons. For such duty the locomotive rarely exceeds a speed of 8 or 10 m.p.h., and since direct drive through the turbo-coupling would only be rarely required, this hydraulic element could be omitted.

In order to provide a high speed for running light, a two-speed gear could be arranged behind the turbine transmission, either low speed or high speed being engaged, according to whether heavy shunting or light travelling were required. A further alternative would be to arrange the torque converter element to work on the normal low speed gear, and to provide a turbo-coupling together with a high-speed gear which can be engaged when in motion simply by filling the coupling. The change over from low gear shunting to direct drive would then simply involve the manipulation of the turbo-converter changeover valve.

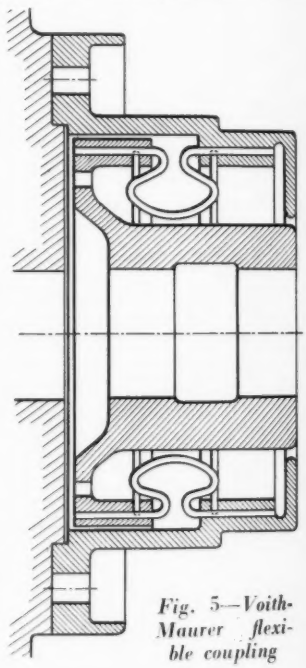


Fig. 5—Voith-Maurer flexible coupling

180 b.h.p. double-engined Austro-Daimler railcar on the Austrian Federal Railways fitted with the Voith-Sinclair type of hydraulic turbo-converter